Royal Commission
on Canada's Economic Prospects

Probable Effects of Increasing Mechanization in Industry

by The Canadian Congress of Labour,
now The Canadian Labour Congress

ROYAL COMMISSION ON CANADA'S ECONOMIC PROSPECTS

PROBABLE EFFECTS OF INCREASING MECHANIZATION IN INDUSTRY

By THE CANADIAN CONGRESS OF LABOUR
NOW
THE CANADIAN LABOUR CONGRESS

SEPTEMBER, 1956

While authorizing the publication of this study, which has been prepared at their request, the Commissioners do not necessarily accept responsibility for all the statements or opinions that may be found in it.

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FOREWORD

The Royal Commission asked the Canadian Congress of Labour to make an "objective study" of "the probable effects of increasing mechanization of industry, and labour's aims and objectives in this regard". It added that the study "might include comments on . . . (a) Transition policies as a greater degree of mechanization (or automation) is introduced, including retraining plans for displaced workers, the problems of workers in the higher age groups, and so on. (b) The long term aims and objectives of organized labour with regard to rates of pay, hours of work, pensions, fringe benefits, etc."

The Royal Commission itself seems to have thought of "increasing mechanization" and "automation" as interchangeable terms. "Automation" is shorter, and is the term most people are now using to cover the whole field the Royal Commission appears to have had in mind. The Congress proposes to follow popular usage, and to consider the whole question under the head, automation.

1

WHAT IS AUTOMATION?

THE FIRST question is, what is automation? Just "advanced mechanization"? Some of it is and some of it isn't.

Edgar Weinberg, in the *Monthly Labor Review* for February 1955 divides it into four forms: (a) automatic machinery; (b) integrated materials handling and processing equipment; (c) automatic control systems; and (d) electronic computers and data-processing machines. The first is clearly "based on engineering principles already familiar in industry". It is just "advanced mechanization", the same kind of thing that has been going on for the last 150 years, but carried to the nth. power; carried so far, indeed, that its effects are often almost revolutionary. The second, what John Diebold calls "Detroit automation", is advanced mechanization plus. It is "a natural outgrowth of both the production line and the machine tool". But it has a new element, which is its "essential characteristic": "the integration of machines with one another". Electric and hydraulic controls "permit the loading and unloading of special purpose multistage machine tools, while large transfer machines provide for the automatic movement of work-pieces from one machine to the next".[1]

The other two kinds of automation involve what Diebold calls "automatic feedback control". This is not based on familiar engineering principles, nor has it grown out of the production line or the machine tool. It is based on different principles, and has grown mainly out of wartime discoveries and experience in electronics and communication engineering.[2]

Of course automatic feedback control is a kind of mechanization. The control systems and computers and so forth are unquestionably machines. But they are a new kind of machines. Like the old machines, they unquestionably are labour-saving. But it is a new kind of labour they save. The old machines saved human muscle. The new ones save human brain. The old

ones had to be controlled and regulated by human beings. The new ones control and regulate themselves.[3]

How do they do it? By what are called "closed loop" systems. The easiest way to understand what this means is to look at some simple and familiar examples of control systems, closed loop and otherwise.

Control Systems

A motor car being driven along a highway is not self-regulating. If it veers too far to the right, the human driver has to intervene and turn it left. If he turns it too far left, he has to intervene again and turn it a bit to the right again. This is an "open loop" system of control. The gap in the circle of control, the "opening" in the "loop", is filled by the human driver. The car is not automated.

An aeroplane on automatic pilot, on the other hand, is self-regulating. If it starts to veer off the beam, the fact of its veering is "fed back" to the instrument, which then causes the plane to veer back on course again. If it started to veer too far back the other way, the same process would bring it back to centre. There is no gap in the circle of control. The "loop" is closed, without any intervention by the human pilot. The plane is, for these purposes, automated.

A street light set to come on at six o'clock in the evening, and go off at six in the morning, winter or summer, rain or shine, is "automatic" in the sense that no human being turns it on or off. But it is "open loop". It is not self-regulating or self-correcting. A London pea-soup fog or a total eclipse of the sun would have absolutely no effect on it.

On the other hand, a street light which would go on whenever darkness fell, from whatever cause, and off again when the sun rose, or popped out from behind the moon or the clouds or the fog, would be "closed loop", automated.

A thermostat is a beautiful example of genuine automation. Once you've set it at the temperature you want, you can forget about it. If the temperature of the room falls below the desired point, the fact makes the instrument start the furnace working. If the temperature rises above the desired point, that fact makes the instrument stop the furnace working.

(Incidentally, automation occurs even in nature. A total eclipse sends hens to roost in the middle of the day, and bright moonlight brings them down. The hen is, in this respect, a "closed loop", completely automated. There is even a commercial application of this: by keeping the hens awake with artificial light you can make them lay overtime.)

What Can Automation Do?

What can automation do? A lot of things; an almost bewildering number and variety.

First, what can Mr. Weinberg's first kind of automation, automatic machinery, do? He answers: "Some types of specialized machinery which carries out a pre-set cycle of operations with almost no human intervention are found today in virtually all plants having a large output of standardized goods. New models of automatic glass-making, textile-spinning, and paper-making machinery, printing presses, and wire-drawing machines are constantly being introduced . . . . A recently developed automatic filling machine, for example, packages cans with four ounces of semi-solid baby food, 'untouched by human hands', at the rate of 800 per minute. The worker's function is limited to manual push-button starting and stopping, observing and adjusting the performance to correct malfunctioning, and repair and maintenance of the mechanism. Such routine decisions as determining when a can is filled are made by tireless, highly accurate, specially designed devices built into the machine . . . New models of automatic machines frequently incorporate devices to save labour in inspecting, gauging, and testing, as well as fabricating operations. Also, labour in servicing machinery is now economized by means of automatic lubrication systems which distribute a precisely measured volume of oil to bearings at regular intervals without direct human intervention."

Fourteen Corning Glass glass-blowing machines, each operated by a single worker, produce 90% of the glass light bulbs used in the United States, and all the glass tubes used in that country's radio and TV sets (except picture tubes).

Automatic manufacture of electronic equipment is a spectacular and highly important example of the same sort of thing. Machines "print" or etch or stencil on a board what were formerly handwired circuits which had to be soldered at all contact points. Machines make the standard electronic components. Machines attach them to the printed circuit boards. Machines make the parts. Machines assemble them. Motorola has a machine that can spit out complete radio sets once the components are fed into it. Raytheon has a chassis-assembly line geared to a thousand radios a day, and operated by two employees, where old methods would have required two hundred. Admiral can assemble half a television receiver chassis in a matter of seconds.

"Detroit Automation"

Faster and larger machines for making things, lead directly to the second kind of automation—"Detroit automation"—automatic machines for moving and handling things. Hand loading and unloading, hand movement of parts

from one machine to another, are expensive. They take a lot of labour, and they are slow, much too slow for the high-speed production machinery. Much of the gain from the heavy investment in automatic fabricating machinery may be lost unless loading, transfer from machine to machine, and unloading can be automated also.

This is precisely what is happening in the famous Rockford, Illinois, shell casing plant, where, once the raw steel stock has been "positioned" at a series of metal-cutting saws by a hand-operated crane, the material is not touched by human hands until the finished shell case is packaged. It is also what is happening in the Ford engine plant in Cleveland. It is what is happening at McKinnon Industries in St. Catharines, Ontario. This plant turns out V-8 engines for General Motors of Canada. "All of the basic work on the engine blocks, more than 800 separate operations, is accomplished with only 27 men . . . These few workers are spread out along 1,020 feet of massive and complex machinery which broaches, mills, grinds, hones, reams, taps, turns the blocks in any desired direction . . . and positions them with pin-point accuracy."[4] Jack Shapiro, describing the same plant on the CBC, says: "It is almost two city blocks long and contains its own railroad . . . At any one time, 104 rough-cast V-8 cylinder blocks are riding it from station to station being machined. At one station a block will be drilled, at another milled, at a third inspected . . . Most maintenance men are eliminated . . . A toolometre . . . counts the number of operations each tool performs. When the tool's life expectancy is exhausted, a red light flashes and the tool is replaced." "Most of the inspection is purely electronic. Even a breakdown doesn't stir up much human activity. Special circuits in each control panel report trouble instantly to a central unit, and the whole line is electronically stopped until the bottle-neck is cleared. Then the same impersonal switches and relays speed things back up to normal again. The line will turn out 70 fully machined blocks an hour—with the expenditure of less than a third of a man-hour of human labour on each."[4] (Incidentally, this example shows how one kind of automation mixes with another: "Detroit automation" with electronics.)

It would be easy to multiply examples: the fertilizer plant which combines everything from loading to bagging in a single automatic sequence, by means of automatic weighing hoppers, screw conveyors and chutes; the processing plants for such bulk materials as cake mix or grain, "built around a system of belt conveyors, gravity chutes, and pneumatic tubes to provide a continuous flow from raw material to finished product;" the automobile bumpers passing continuously through a 31-step process, guided by a combination of shuttles and elevator;[5] and the automatic assembly of automobile frames.[6]

Automatic Controls

Automatic controls can be applied most easily to industries or parts of industries in which production can be reduced to a continuous flow. The most obvious examples are industries dealing with liquids, gases or electric energy: oil refining, oil pipelining, chemicals (including atomic processing), beverages, plastics, paint, rubber, flour milling, cement, electric power, telegraphs, telephones, continuous production of sheet steel and steel castings.

A modern oil refinery is almost completely automatic, and would be impossible if it weren't. The processes are too swift and too complex to be handled any other way. There are still a few workers in the plant, but their job is ordinarily confined to watching instruments, sometimes helping or correcting them, and starting and stopping the whole thing, usually about once a year. In the new Petrofina refinery near Montreal, an "automatic logger" will analyse and report 400 process variables, including temperature and pressure in the nine production units; automatically type entries on a log each hour on the hour; report abnormal conditions in between times; and, if there is trouble, signal an alarm and immediately pinpoint the abnormal condition.

The new CIL polyethylene plant at Edmonton is almost completely automatic, and has an output of about $40,000 per worker per year. A single operator runs a sizable American high-purity hydrogen plant.

A conventional plant of the Cleveland Electric Illuminating Company employs a hundred men for 290,000 kwh of production; its new, largely automatic plant employs twenty-eight men for 420,000 kwh.

The telephone industry was, of course, one of the first to feel the impact of automation. Most local calls in most Canadian cities are now made automatically, and in the United States the same thing is about to start happening to long distance calls. The first installation began to work in May, 1956, and covers southwestern Ohio and some points in Kentucky. By 1960, Columbus, Toledo, Detroit, Chicago, Cleveland, Indianapolis, Pittsburgh and perhaps other cities will probably have been added to the dialing range. When the customer dials the out-of-town point, the equipment will record his number, the number he is calling, how long he talked (or a busy signal, or no answer) on a punched tape. These tapes will be decoded by machines which will assemble, translate, sort and summarize all billing information. In short, the customer will make his call and be billed for it without the intervention of any human being but himself. The Bell system is also introducing a machine to put together complex wiring circuits; electronic test sets which automatically test cables during wet weather; microwave stations that will eliminate countless miles of poles, cable, wire, cross arms and maintenance on these facilities; new types of central office equipment that will virtually eliminate maintenance; automatic power plants which will cut in and out auxiliary

power supplies; a plough that can lay fifteen miles of cable per day (digging the trench, laying the cable, and covering it in a single operation) with a crew of "less than seven men".[7] (Here, again, the automating is not just a matter of one type, automatic controls; the different types overlap.)

Automatic elevators are replacing not only operators but starters. In a big Milwaukee tannery, automatic controls now mix the acids and oils and regulate the temperature while conveyors put the hides through various processing machines.

Railways are going in for electronic yards. Hitherto, the yards have been the main bottleneck in railway operations. Now, in such yards as Union Pacific's, at North Platte, Nebraska, a switch engine pushes a string of freight cars up a hump where they are uncoupled by hand to roll down hill untended. So far, nothing new. But as they begin to roll, the tower man presses a button for each car's destination. Switches are automatically lined up by electric relays. Each car's speed is gauged by radar; and a computer which is fed data on wind resistance and track curvature figures the proper speed for the car's cargo. Automatic retarders control the speed. Soon the car bumps gently into the proper train. The "gently" is very important, because it both protects the freight and reduces the need for repairs to the car itself, and hence the time lost to the railway. At Bensonville, Illinois, the Milwaukee Railway's yard had a damage bill of only $896 for 74,855 cars, a fantastically low rate. The Rock Island Railroad expects to put into its Chicago yards a printer (with detailed cargo and destination information for all cars) to cut a tape. When the train gets to Silvis and is ready to be shoved over the hump, the tape will be fed into a machine which will automatically line the switches and adjust the retarders to handle the classifications of the train.[8]

Recently, Dominion Foundries & Steel Limited at Hamilton installed a new 56-inch cold mill guided by electronic controls, manufactured by Canadian Westinghouse. "The new Dofasco mill thins out steel strip after it can no longer be reduced by hot-rolling. The coiled steel arrives at the plant for cold-rolling after a pickling operation has removed the scale formed during preliminary hot-rolling operations. Each of the coils contains about 1,500 feet of steel strip. The end of the coil is fed between the rolls of the mill and almost automatically the rolls of the new mill go to work guided by a 'brain' which features the latest in electrical control equipment.

"The mill operator at a control desk first selects the speed and tension for the mill's four rolls and chooses the desired thickness of steel. Then he merely pushes a button to start the mill and pushes another one to stop it. Complex control board equipment receives the selected information from the operator's control desk and relays it to the mill's eight motors. Six motors, totalling some 8,000-horsepower, power the mill when steel is being reduced and two other 400-horsepower units go to work when a tempering operation is required.

"The regulating equipment on the control board ensures that the speed and tension of the steel going through the mill remain constant, even though the coils unwind and build up between 20 in. and 60 in. between each pass. The steel is rolled and pulled to the required thickness with the original 1,500-foot coils frequently stretched to 15,000 feet before the rolling is completed. Said to have the fastest and most powerful reversing cold mill drive in North America, the new mill can process as much as 3,000 feet per minute by reduction to .006 or work tempering."[9]

Electronic Computers and Data-Processing Machines

The mention of computers in the automatic railway yards brings us to Weinberg's fourth form of automation: electronic computers and data-processing machines. What can they do?

There are two types of computers: analogue and digital. Analogue computers measure. Digital computers count.

Analogue Computers

A speedometer or an electric meter is a simple example of an analogue computer, though of course neither is electronic. They are very humble brethren of the giant "Project Typhoon", with 6,000 plug-in connections, 100 dials and 4,000 electron tubes. But they all do the same kind of thing. The big, elaborate, electronic new ones are used "to derive answers to engineering problems from the operations of a physical analogy of the problem".[10] The engineer can build an analogue, or model, of a missile or a utility network or an industrial process, and, by studying how the model reacts to various conditions, learn how the actual missile or utility or process would react under similar conditions. The model may not be a bit like the real thing in form (quantities may be represented by physical distances, or varying electrical voltages), but it behaves in the same way. And, as it is much smaller and cheaper, the engineer can experiment easily, cheaply and quickly without using up a lot of costly materials or risking damage to a lot of costly equipment to no purpose.

One analogue computer saved the American Navy more than $250 million by making over two thousand "test runs" of proposed guided missiles.[11]

The only electronic reservoir analyser in Canada is found in the Research and Technical Service Building of Imperial Oil in Calgary. "When put in operation, the machine actually becomes an electrical counterpart of the oil field under study. When the known information about a field is fed into it, the analyser foretells just how an oil field will operate in the future under whatever conditions the researchers choose. Thus the life of the oil field is clicked off—month by month in a matter of minutes. Armed with this in-

formation, the research staff learns at what rate oil should be withdrawn from the coils unwind and build up between 20 in. and 60 in. between each pass. oil field lost its natural pressure, the oil man shook his head and moved on. Perhaps more than half the field's oil remained in the ground, but could not be recovered. By finding ways to augment the natural pressures that force the oil out of a field, research has changed all that. Today the oil man is confident that application of artificial energy will recover probably two-thirds of a field's oil, in many cases."[12]

Analogue computers are also used in industrial controls, notably in the Arma automatic lathe and in oil refining. In general, the cost curve of analogue computers rises lineally with the complexity of the job, while the digital cost curve is fairly flat. Also, the error of analogue computers increases with wear and tear and other degradation, while the digital computer goes on steadily till a catastrophic failure. In oil refining, where catastrophic failure simply cannot be tolerated, analogue computers are inescapable. The MIT milking machine uses both analogue and digital computers.

Digital Computers

Digital computers are much more exciting and romantic. They are the raw material of much science fiction. They are the "electronic brains" which seem to be able to do everything but fall in love. All they can really do is count: add and subtract at fantastically high speeds. As multiplying and dividing are really just forms of adding and subtracting, the computers can do those also. They do it by means of electronic tubes and "binary numbers" (one and zero). The tubes either have current flowing or they don't. If it is flowing, that corresponds to one; if it isn't, that corresponds to zero. Ordinary decimal numbers have to be translated into binary numbers before the machine can handle them. But once that is done, and put down on punched cards or paper tape or magnetic tape, and fed into it, away it goes, like lightning. As words can be translated into numbers (the whole alphabet can be represented by combinations of one and zero), which the machine is built to handle, the computer can deal with any kind of information, once it has been put into the "language" it "understands", and deal with it, again at almost incredible speeds. Logical problems, stated in word symbols, become mathematical problems, stated in numbers, and the machine can then solve them. That is why the computers can compare, collate and choose between logical alternatives. They can "see", "feel" and "hear". They can store information and pull it out again when they need it. The newest IBM machines can even talk to each other on the telephone, and act on what they hear. "Using a beep-beep language of their own, they swap information at the rate of one thousand numbers or alphabetical characters a minute."[13] There is even an electronic mouse with copper whiskers which finds its way through a complicated maze to a brass "cheese" first by trial and error, then, unerringly, by the right path.

So these machines seem to be able to "think", "remember" and "learn". They seem to be "giant brains". But in fact all they can do is to follow instructions, which must be simple and unambiguous. Once the instructions are fed in, the machine will do the rest. But no instructions (or no instructions the machine can understand), no answers. Some people believe we shall ultimately be able to make machines that will originate things, really think. But at present we certainly can't, and it is extremely improbable, to say the least, that we shall ever be able to do it economically. Mr. Warren McCulloch, psychiatrist of the Illinois Neuropsychiatric Institute, told a group of engineers in New York: "The Statler Hotel could not house a computer with as many relays as you have in your head. It would take Niagara Falls to supply the power and the Niagara River to cool it."

However, the important thing for us now is not what the machines (present or future, actual, probable or improbable) can't do, but what they can—which is plenty.

For the digital computers can not only "process" a great variety of information, but, if they are connected to the proper equipment, can take all necessary action involved in the answers. That is why digital computers can do all the bookkeeping and accounting work of a business. That is why they can also regulate the operations of a whole industrial plant, once it has been put on a continuous flow basis, or regulate such parts of the operations as have been put on such a basis. With computers, we can introduce end-point control, where a change in the requirements of the final product automatically produces the necessary changes at each stage in the process. The computers, propertly instructed, can not only tell us what to do but do it for us. They can give orders like start or stop, up or down, right or left, forward or back. They can make decisions like "too hot" or "not hot enough", "empty" or "full", "too fast" or "too slow", or any other choice that does not involve more than two alternatives. (The choice is limited because each of the switches inside the mechanical "brains" can turn only "on" or "off".)[14]

What are they doing now?

Office Automation

Insurance companies are automating their offices with computers. Prudential, in the United States, has one "that will bill policy holders for premiums, figure agents' commissions, calculate dividends and work out all the statistics on which premium rates are based. Officials estimate that (it) will take over the work of 200 human employees in one department alone".[15] Developments like this could reduce necessary storage space from ten to 15 floors to one medium-sized room.[16]

General Electric, in Louisville, Kentucky, uses its Univac computer to make up the weekly payroll for 12,000 employees. "It adds bonuses earned,

makes income tax deductions, figures overtime—all the things a payroll clerk has to do to a pay cheque in mid-twentieth century. It distributes all totals among the cost accounts of the company's various departments. Then it writes out a cheque for everyone concerned, prints a payroll register, and reports ready for the next job. The whole complex process takes less than six hours."[17]

Our own Department of National Health and Welfare has largely automated the sending out of its 3 million Family Allowance Cheques each month. A few addressograph machines, each operated by two men, write and sign the cheques mechanically, using specially prepared plates. This requires 286 man-days per month. By the old method, it would take 6,000 typist-days per month just to write the cheques, and another 10,000 man-days to sign them and to check for accuracy. So the machines save 15,714 man-days per month. A lot of man-days, of course, are needed to cut the plates. But the plates are used for a variety of other administrative purposes, so only part of this time should be deducted to get the net saving; how much, nobody knows. Clearly, however, the net saving must be enormous.

Other machines pick up the cheques, put them into envelopes and seal and count the envelopes. This saves another 357 man-days.

Other machines automatically punch holes in the cheques. When they have been cashed, they come to the Cheque Adjustment Branch in Ottawa, where other machines sort them in numerical sequence, registering the number and amount of each cheque, and the office, year and month of issue; and then balance them with the bank statements and make a reconciliation of paid and outstanding cheques. All this means a net saving of about 4,850 man-days per month (pretty close to $600,000 a year, incidentally).

Postage meter machines eliminate the need for stamping the envelopes by hand. This saves another 273 man-days per month.

The total net saving must be between 15,000 and 20,000 man-days per month.

The C.P.R. has installed in its Montreal offices a computer which, according to a *Montreal Gazette* story of July 7, 1955, is now, or soon will be, handling 5 million way bills, 9 million passenger tickets and 1,800,000 requisitions on stores. By giving this machine a thousand or more logical instructions prepared in advance and retained for repetitive operations, one processing of tapes will produce, automatically, in a few hours, an engineman's payroll, showing semi-monthly gross earnings, deductions for income tax, pension, union dues, hospital association etc., and in the same operation print pay-cheques and coupons and a statement of the wages according to the operating divisions and account to be charged. The machine can also print a statement of wages for each train run and each class of train or service, summarizing the dead-heading, overtime, and so forth. It can also

produce a statement of locomotive miles and fuel consumption by classes of service and train runs, and other statements analyzing various phases of information drawn from the trip ticket.

The C.N.R. is proposing to automate its Canadian revenue accounting office in Montreal, employing about 1,200 people.

Computers are replacing clerks to register and allot train and aeroplane reservations (the Pennsylvania Railroad's Intelex and American Airlines' Reservisor). The Toronto Stock Exchange has a machine like Reservisor which transmits quotations to brokers on demand.[18] The Bank of America has a computer which will do the job of many employees. When a cheque comes in, an operator punches the amount into the machine. The cheque carries a code, printed in magnetic ink, which identifies the account number. The machine scans this code. It then refers to its "memory bank", which contains information on 32,000 separate accounts, makes sure there is enough in the account to meet the cheque (or flashes an "overdraft" light at the operator's desk), checks to make sure there is no stop-payment order, then deducts the amount of the cheque from the account, all in about one second. The transaction is recorded in a "temporary memory bank", and transferred later to a "permanent memory bank". At the end of the month, the machine automatically calculates the service charge, and then, connected to a high-speed printer which can print 800 characters a second, prints the customer's complete monthly statement in less than five seconds. Nine operators and one such machine can replace up to fifty bookkeepers.[19]

The First National City Bank of New York has a machine which even does the job of punching the cards to be fed to the computers. This gadget "reads" the serial numbers on travellers' cheques and reproduces them on punched cards at a rate of 7,200 per hour, doing the work of ten operators.[20] "Fosdic, a mechanical employee of the U.S. Census Bureau, reads forms submitted by census takers, picks out the right information from corresponding columns, adds five million answers in half an hour, and files it all away in a microfilm library."[21] Our own Census, in 1951, used a mark-sense card in place of its traditional line schedule. The marks made by enumerators were read by document-sensing machines and cards were punched mechanically. This saved much work that had previously gone into manual editing, coding and punching of population schedules. The cost was cut almost 45%.[22]

Some American public utility companies are using computers to do most of the work of billing customers from the moment the meter reader brings in his marked card. A mark-sensing unit translates the marks into punched holes, and punched card accounting machinery does the rest, including printing the bills. Further developments may eliminate the meter reader by eliminating the meter.[23]

Inventory Control

A large Chicago wholesale mail order firm recently installed a device called the Distribution for inventory control purposes. This machine "can make available immediately: total orders for any catalogue item; printed record of transactions for any item or items; printed record of the complete inventory in less than three hours. It can sort figures into 39,000 classifications, adds as it sorts and registers all totals".[24]

A warehouse of Imperial Oil Limited at Sarnia was built as a central source of supply of material to field warehouses in various locations. "The warehouse supplies only packaged items, but there are also about 120 tanks for bulk storage, and packages are often filled directly from the bulk storage tanks. The Marketing Research group of the company had worked out a system of inventory control, and was eager to make a check on the effectiveness of the operation. The problem was submitted to the Computing Centre of the University of Toronto, which undertook to programme a simulation of the entire warehouse system, for processing by 'Ferut', the University's electronic digital computer.

"The computer programmers re-created, as far as possible, the actual operation of the warehouse in a given year, basing their programme on the available statistics. They fed into the machine, in appropriately numerical form, some 1500 items of inventory, then processed orders exactly as they had been handled in actuality, and with due consideration to such variables as the availability of blending and filling equipment for packaging from the bulk tanks.

"The output pin-pointed the trouble points or possible trouble points in the system, and made available valuable information about peak and slack seasons, periods of overtime operation of the filling equipment and other periods of excess capacity, danger levels and run-outs, and all failures to meet orders. The machine was able to define exactly the ways in which the system did not satisfy its requirements, and established a standard of performance by which operations can be measured in future.

"The particular application of the computer to this problem points the way to a possible general application. This would make available a standardized programme that would work for all inventory systems, whatever the material involved.

"Such a standardized system, the University's computing staff believe, is well within the capacity of the electronic computer. It could set up a criterion which would enable any business to establish whatever level it may consider optimum with regard to inventory—whether the aim be to meet all orders, to keep the tied-up capital at a minimum, or whatever—and to operate the system at peak efficiency."[25]

Invoicing

The largest wholesale drug house in North America is the Drug Trading Co. Limited in Toronto. "Its invoicing department handles an average volume of 40,000 line items per day by means of an International Business Machines punched card system which was installed five years ago. The IBM system replaced a completely manual operation which was proving inadequate to keep abreast of the daily volume of orders, at that time in the neighbourhood of 20-25,000 items per day. If the business continues to grow at its current rate, the punched card system will be as inadequate in five years' time as the manual system was six years ago, so the company is preparing to replace it with an electronic data processing machine—the '705' of International Business Machines.

"In order to appreciate the capacity of the '705' to provide improved handling of the company's invoicing procedure, it is necessary to understand something of the present system of invoicing. The hub of the present system is an area of large open files, known as tub files, which contain 7 million punched cards in two identical file setups of 3½ million cards each. These contain all relevant information on each item sold by the firm, and are filed in alphabetical order under the commonly known name of each item. The cards are coded to correspond to a very large number of variations having to do with such things as quantity, type of packaging, discounts allowed, etc. There is also a master file of heading cards, each of which contains only the name and address of a customer.

"As an order is received, it is attached to the appropriate heading card and passed to a 'starter' who places the orders in sequence of delivery. The company has 36 delivery routes in Toronto and two in Hamilton which are covered twice a week, and also delivers to five outside points once a week. The orders must be scheduled for the appropriate delivery route and this routing is what the starting desk accomplishes.

"The order with its attached heading card is then passed to a card-pulling clerk who pulls from the tub file the detail cards corresponding to each item on the order, and who is thereafter responsible for seeing that the order is filled. The card-puller, having 'mark-sensed' the item card (with a special pencil that makes electrically-conductive marks capable of being 'read' by the accounting machines) for price, quantity, and whatever other information is relevant, sends it, together with the heading card for each order, to the machine room. The original order goes elsewhere for further processing, and eventually one copy of it is stapled to the invoice produced in the machine room. In the machine room, various machines 'read' the cards for the quantity of each item required, sort them to the location of the stock in the warehouse, and produce a printed invoice, bill of lading and shipping case label.

"One copy of the invoice produced in the machine room is sent immediately by pneumatic tube to the warehouse starting location, and from it the order is filled. A second copy is matched to a copy of the original order, stapled to it, and sent to the end of the warehouse filling line. There, where the packed order is ready for shipment, the two copies of the invoice are checked against each other, and any necessary changes are made. One copy is included with the filled order and shipped; the second is retained by the accounts receivable section.

"The '705' electronic data processing machine will do away with the present tub file system and so effect a great saving of space. It will also perform the necessary accounting procedures much faster, and will keep a perpetual inventory of all items stocked, accounts receivable file for all druggists billed, automatic re-ordering of depleted stock, and accounts payable files for vendors. All these records will be maintained on magnetic tape, and through the high speed of magnetic tape handling (15,000 characters per second) there will no longer be the necessity of maintaining tub files. In place of the large area now occupied by these files, there will be a single machine, whose magnetic tape 'memory' will store every possible piece of information about every item sold by the company.

"The '705' can process 2,100 feet of magnetic tape—the equivalent capacity of 50,000 punched cards—in six minutes. It will automatically compare the total of each order with the customer's account for a credit O.K., and will even determine the action to be taken in the event that the credit is dubious. It is even capable of automatically writing a letter to the customer bringing an over-due account to his attention! In four and a half minutes the machine can provide a complete inventory of everything in stock, and in a further 15 minutes print a translation of the inventory in writing."[26]

Even unions are automating. When the railway non-operating unions got the check-off, the largest of them, the Canadian Brotherhood of Railway Employees and Other Transport Workers, faced a problem that was virtually insoluble with its existing methods. The railways sent the Brotherhood's national headquarters strip copies of their payrolls, with a cheque covering the lump sum payment from each railway region. The Brotherhood had to distribute the 210 local divisions' share of the dues each month. This meant it had to prepare statements listing the name of each individual who worked within the jurisdiction of each local, and had to forward this statement to the division's Financial Secretary with a covering cheque. With the old methods, using Burroughs Bookkeeping Machines, and other traditional equipment, this would have taken 2,334 man-hours of work per month. The new IBM equipment handles it easily with 665 man-hours, and could do a good deal more without any increase in man-hours required. The old method, doing the new job, would have cost about $2,400 a year extra for rental of extra space, $22,500 extra in wages, and new capital investment of $11,000.

Non-Office Jobs

These are office jobs. But the computers don't stop at those.

The Ohio Edison Company is installing a central computer which will simultaneously control the operation of 35 generators in nine plants spread over an area of 9,000 square miles, deciding which generators to use, and turning them on and off.[27]

"One company recently demonstrated a robot toll collector for bridges. It will make change, count the number of cars going through and balance the cash at the end of the day. If any mere human being thinks he can drive past this electronic watchdog without paying, the machine slyly takes a photograph of his rear license plate and passes it along to the local constabulary."[28]

"In manufacturing, highly trained die cutters are losing jobs because of machines that will make as many perfect copies as you want from a single master die. Even the master die may not be cut by a human being much longer. (With) a million-dollar machine being installed at the Convair plant in California . . . all that's needed is a blueprint of a newly designed part, which no one has ever made or even seen. Engineers can punch out instructions on a tape which will tell an electronic brain what tool strokes are required to make it . . . This machine can switch from one kind of part making to another just as fast as instruction tapes can be changed . . . It is capable of 18 different machining operations."

"Electronic brains have also moved in on the baking industry, with taped formulas for turning out bread, cake or pretzels—including bending them."[29]

"Job Shop Automation"

The Convair machine which can switch from job to job illustrates a most important point. "Detroit automation", with single purpose machines operating on discrete parts and linked by materials-handling conveyors and transfer mechanisms, involves high initial costs. It is worth while only for very long single-product runs. Only a few major industries can afford it.[30]

But "tape control of machine tools provides a flexible method for producing small lots. With this type of automatic control, the tool is guided over the work without human intervention in response to a series of instructions previously recorded in code on such media as cards, paper tape, magnetic tape or film. These instructions can be changed after each job".[31] "In job-shop automation, smaller and more versatile machines, such as milling machines, drills and punch presses, can be automated by servo-mechanisms and tape or contour-following control."[32]

This is very important because as Diebold points out, "Most" even "of American industry . . . depends upon short runs of product. About 89% to 90% of all American production is in lots of less than 25 individual pieces. It is impossible to build special-purpose machines to manufacture these, because the character of the product changes too frequently . . . Traditionally it hasn't been worthwhile to put in automatic machinery because you have to change it frequently and your investment would be enormous to do this. If you can use machines of this type, you can store the tapes. You can put it on a shelf.

"If you make 10 of these units now and 10 later in the year you can store the tape. This has a number of implications. It has significance in such areas, for example, as aircraft manufacturing, if we were to try to put planes out at the same rate that we were forced to put them out during the Second World War, at the rate of one an hour in some of our large bomber plants. The changes in the technology of the planes themselves, the increases in the speeds, have meant a decrease, for example, in the thickness of the wing. It has become necessary now, instead of fabricating the wing, instead of putting it together by sheets of metal, to carve it out of solid blocks of metal. To do this by hand-controlled machines is an almost impossible task. It means that hundreds of hours of machining time have to be put into each part. In terms of the connecting unit between the wing and fuselage of one of our planes—I think there are about 120 hours of machine time on that particular part, for each side of the plane—it would mean if you wanted to turn them out one an hour, you would have to have 240 machines of this type to do it.

"This would be of that particular type of machine tool, about an eight years' output of the industry. The military catastrophe that would result from reliance on such techniques is, I think, very plain. By means of tape controls it is possible to store this information in a tape, to use a machine that can operate much more rapidly, or cut metal at a higher rate than can a traditonal machine tool and to quickly adapt a large enough group of general purpose machines into highly automatic special-purpose tools for quickly producing the necessary output.

"It means you can vary the characteristics of the plane. You can change it from plane to plane, and the engineering changes in the aircraft industry are enormous. There are a great number of industries where ability to change is important."[33]

The importance of job shop automation will obviously be even greater in Canada than in the United States, since short runs must constitute an even larger proportion of our production than of theirs. It is worth noting also that Diebold told the Congressional subcommittee[34] that "This kind of automation is just beginning to have an impact. It gives every impression of taking a very long time to come about."

In the packinghouse industry "the removal of hides from slaughtered animals used to demand high manual dexterity. Now an automated system largely developed in Canada does the whole job after a semi-skilled worker makes a single incision. Where it formerly took 98 top-rated hide strippers to skin 110 steers per hour, the latest figure at Canada Packers in Toronto is 47 men to maintain the same rate".[35]

Other examples may be found in the basic steel industry. "Perhaps the most spectacular of these is the continuous strip mill, which entered upon the scene in the early 1930's. It produces steel sheets among other products. Previously, this flat rolled product called for movement from place to place, being finished on a hand sheet mill. This was hot, laborious work. Now, a thick slab of steel enters a series of rolls, propelled by mechanical power, each set reducing the thickness, increasing the length, and propelling the steel to the next set of rolls, until the steel finally is of the desired gauge. Automatically it is then wound like a ribbon on a roll. Buttweld tubing is also produced through an application of this continuous flow principle. A spool of flat steel is unwound by mechanical power, the steel then proceeds through a heating furnace travelling slowly enough to be heated to the proper temperature. At the other end of the furnace it is pulled through a funnel-like device which curves the steel ribbon, and the heat of the steel itself welds the edges together into a pipe. There are many applications of this 'ribbon on a spool continuous flow' process."[36]

2

HOW FAR WILL AUTOMATION GO?

Obviously, the probable effects of automation will depend largely on how far it goes: how many industries it affects, and how much it affects them. After the long and varied list of examples just given (and they are only a random handful, most of them chosen because they are Canadian), these questions may look foolish. Is there anywhere automation will not go? Are there any industries or activities which will not be automated?

The soberest expert opinion, however, seems to be that there are in fact a great many places automation will not go or will not go far, a great many industries and activities it will not take over or will take over only in part.

The experts may, of course, be wrong. If they were, it wouldn't be the first time. In June 1908, Professor William H. Pickering, of Harvard Observatory, writing in *Aeronautics,* said: "The popular mind often pictures gigantic flying-machines speeding across the Atlantic carrying innumerable passengers in a way analogous to our modern steamships . . . It seems safe to say that such ideas are wholly visionary, and even if a machine could get across with one or two passengers, the expense would be prohibitive to any but the capitalist who could use his own yacht. Another popular fallacy is to expect enormous speeds . . . Another popular fallacy is to suppose that the flying machine could be used to drop dynamite upon an enemy in time of war."

After that, even the scientist, much more the layman, may well hesitate to set limits to what automation can do; the more so as most of the practical applications of electronics date only from about 1940, and most of the civilian industrial development only from about 1945. Automation has passed far beyond the experimental stage, and far beyond the stage where it is a rare and isolated phenomenon. It is working, working with almost frightening efficiency, working on a large scale, all over the place. That is undeniable. But it is equally undeniable that it is still in an early stage of its development.

It is going places and doing things in a big way; but it is certain to go more places and do more things, and in bigger ways.

No less important is the speed at which the technical development has taken place so far, is still taking place, and seems likely to go on taking place. ENIAC, one of the first computers, built in 1945, solved in two weeks (during which it actually worked only two hours) a problem that would have taken a trained human computer a hundred years. But ENIAC is now described as "primitive" compared to present machines of the same sort. In 1952, a University of Toronto computing machine could multiply 500 pairs of seven-figure numbers in two seconds; but in 1953 the American Atomic Energy Commission produced a machine which could multiply a pair of twelve-figure numbers 2000 times in one second.[37] "A machine introduced in 1953 had 25 to 35 times the speed and capacity of the first large electronic computer produced by the same company in 1948.[38] David Sarnoff, of RCA, says that the new technologies are going forward at "increasing speed . . . We are merely on the threshold of the technological age".[39] Before the war, a colour offset could do 4,500 revolutions a minute; the new ones can do 8,000. An automatic teletype-setter can do 300 words a minute, and the new High Speed Fax 3,000. The Flying Typewriter, an electronic printer, could do 24,000 characters a minute, or five lines of type per second; a few months after it appeared a Synchroprinter doing 36,000 arrived on the scene. "Ultrafax" is faster still, combining television, radio-facsimile relaying and high speed motion picture photography: *Gone with the Wind* was transmitted and reproduced at a rate of a million words a minute.[40]

We are only at the beginning of the development of the transistor, the "tiny, highly efficient successor to the vacuum tube", which will make possible portable radios "of hearing-aid size running indefinitely on one set of batteries"; RCA in November 1952, exhibited an automobile radio operating directly off a 6-volt automobile battery.[41] Dr. K. R. Patrick, in his brief to the Royal Commission, says that within ten years "television sets will be transistorized, highly portable, probably no larger than a small table radio, and capable of projecting a picture from a flat light amplifying surface which can be hung on the wall, or in any area in the room". He adds that "colour television will be introduced into Canada during the next two or three years with half the television sets being sold in 1960 probably being full colour sets. Within ten years, and because of long range communication systems now under development it will be possible for Canadian viewers to see programmes from the United Kingdom, Europe and other distant places, with the same technical performance now enjoyed from local stations . . . There will be magnetic tape recordings of movies which will feed into a television set just as a phonograph record feeds into a radio set today."[42]

"In ten years", Dr. Patrick proceeds, "there will probably be an electronic device to succeed refrigerators, deep freezes and conventional air

conditioners. One can visualize the average home of 1975 complete (sic) air conditioned by electronics to the same extent it is equipped today with radio or television . . . Industry will have infinitely better communication. In 20 years businesses with branch offices or remote operations of any kind will probably handle all of their communications over a closed circuit television system which would provide immediate transmission of letters, drawings and other written materials."[43]

We are also just at the beginning of the use of ultrasonics and infrasonics. An infrasonic oil well pump vibrates more oil out of the oil-bearing sands and strata. Ultrasonic vibration will clear the air by "lumping" dust and smoke particles. A sound generator, with high frequencies, will mix and homogenize paints, chemicals, medicinal and food preparations (oil and water can be mixed in this way to stay mixed for years!). Milk can be homogenized ultrasonically without heating it; juices can be sterilized in the can without affecting their flavour; solids can be shattered or heated to decompose or burn; germination and growth can be speeded up; clothes can be cleaned by ultrasonically shaking the dirt off the fibres.[44]

Physical Possibility vs. Economic Possibility

Physically, technologically, there may be very few industries or activities that cannot be automated, sooner or later. Economically, there may be a good many which are most unlikely ever to be automated, or at any rate fully automated. Someone once said that whatever is physically possible is financially possible. In one sense, of course, that is true: physically, we could grow bananas in Canada, by reproducing artificially here the soil, temperature and other conditions of the countries in which they grow naturally; and if we wanted to do it badly enough, no doubt we could find the money. It would be both physically possible and financially possible. But no one in his right mind would try to do it as a commercial enterprise. That is why "Whatever is physically possible is financially possible" is, for practical purposes, dangerous nonsense.

What is the point of this in relation to automation? Simply that there may be a lot of things the automatic machines and the control mechanisms and the computers *could,* physically and technically, do, but for which they would cost too much. Physically, no doubt, an electronic machine could do all the corner grocer's bookkeeping and send out all his bills. But it would cost him more than he could make in a lifetime. Whether the electronic machine will eliminate the corner grocer is another question. The point, for the moment, is simply that physical possibility and economic possibility are two different things; and it is economic possibility that matters.

Mr. D. J. Davis, vice-president, Manufacturing, of Ford, told the American Congressional subcommittee that "Automation . . . cannot be engineered

into every job indiscriminately, since it is not always feasible or profitable. Each application . . . must be carefully analyzed before it can be justified. If either daily volume of the part is low or long-term use of the machine is limited, any possible direct labour savings through automation are reduced and may be offset by increased maintenance costs and depreciation or obsolescence. For example, we can economically justify the application of automation to the manufacture of engine components for the Ford engine. The same extensive application of automation, however, cannot be justified on the tractor and Lincoln engine components, due to their lower volume requirements.

"As we now see it, there is also little prospect for extensive application of automation in our car-assembly operations, where we assemble in 20 different locations and are faced with technical problems and early changes in product design . . .

"Totally, in the company, perhaps only 6% of our employees, direct labour employees, work on automated lines."[45]

Mr. R. C. Tait, president of Stromberg-Carlson, discussing automation in wiring and assembling radio chassis, told the same sub-committee that "the entire direct labour costs in a manually wired and assembled radio chassis of this type often constitutes less than 3% of the selling price of the set . . . The major cost of the product is in the components, and redesign requirements for automation must not increase these costs by even a fraction of a cent or the possible labour savings are more than offset."[46]

Similarly, Dr. Cledo Brunetti, Director, Engineering Research and Development, General Mills, Inc., describing that company's "Autofab" automatic electronic assembly machine for radios, told the subcommittee that "the machine cannot put in and align tubes and test the final assembly, put in the cabinet or attach knobs, dials, and decorative effects. It does not pack the final product, does not ship it, and certainly does not market the product. The mechanized part accounts for only a small portion of the total working force."[47]

What May Not Be Automated

Professors Buckingham and Dallas, addressing the Southern Economic Association, November 19, 1954, said:

"For the purpose of determining the extent to which automation can be applied to productive processes, industries can be divided into three classifications. The first includes those industries in which production can be reduced (to) a continuous flow process. Oil refining, flour milling and chemical production are illustrations of industries in which automation has made, and should continue to make, significant progress. In other industries it is

possible to revamp the productive mechanism in such a way as to convert it from a series of unit operations into a single endless process . . .

"A second class includes industries in which some automation is possible, but full or nearly complete automation is not likely. Indeed, it is possible that some industries may have automatic machines applied to 75% of their operations, yet the cost of making the plant completely automatic would more than offset the savings achieved from the use of partial application of automatic machines. In this category would be found industries which require substantial information-handling and accounting functions but in which the method of production or the nature of the product is not adaptable to continuous flow techniques. Such industries would include transportation, large-scale retailing, and the manufacture of certain nonstandardized consumer products like furniture.

"The third group . . . includes those in which the highly individualized nature of the product, the need for personal services, the advantages of small-scale units or vast space requirements preclude any significant application of automatic controls. These would include agriculture, mining, professional fields, and most construction and retailing."

They conclude that revolutionary changes are likely to affect only a limited sector of the economy, that "automation will be limited to industries which employ, at most 25% of the labour force."

This may be an underestimate, but, lest it should be dismissed as merely wishful thinking or propaganda by captive economists of big business, it may be as well to add that Professor Buckingham was one of the main speakers at the Conference on Automation convened by the CIO Committee on Economic Policy in April 1955, some months after he had delivered the paper just quoted from.

Diebold says it is hard to make a "definite prediction", but he is confident that agriculture, trade, service, construction, mining and the professions will not be automated, though they will use automatic machines. In 1949, he adds, these industries, with the self-employed, accounted for over 56% of the American labour force.[48] In Canada, at present, the same industries account for about 60% of our labour force with jobs, and about half our paid workers (wage and salary earners).

What May Be Automated

In the same book,[49] Diebold quotes "an excellent unpublished paper", *Automation in the American Society,* by Richard L. Meier, a physical scientist of the University of Chicago, as suggesting that the following American industries are ripe for automation: bakery products, beverages, confectionery, rayon, knit goods, paperboard containers, printing, chemicals,

petroleum refining, glass products, cement, agricultural machinery, miscellaneous machinery, communications, limited-price retailing, and some miscellaneous items. These industries account for about 8% of the American labour force. The corresponding industries in Canada would account for about 11% of the wage and salary earners covered by the DBS *Employment and Payrolls* (which covers about 60-65% of the total wage and salary earners).

Mr. H. de Bivort, in a valuable article in the *International Labour Review* for December 1955,[50] cites various authorities for the statement that "industries where a high degree of automatic production has already been or is likely to be achieved include chemicals and liquid fuels, cement and brick, beverages, fibre and textile products, paper products, glass and ceramic products, machinery and machine-tool production, mining, communications and some areas of retail trade. Industries considered likely to be only incidentally affected, although able to use some automatic machines, include agriculture, transport, construction, forestry and wood products, the garment industry and shipbuilding".[51] This list of industries "where a high degree of automatic production has already been or is likely to be achieved" would account for about 18% of the wage and salary earners covered by *Employment and Payrolls*. The big difference, of course, is the inclusion of mining in the second list. The two lists together would account for about 20% of the wage and salary earners covered by *Employment and Payrolls*.

The differences in the two lists show how unsafe it is to be dogmatic on this subject. But if estimates like these are anywhere near right, a considerable proportion of our industry will not be directly affected by automation to any serious degree. The indirect effects even on these industries might, of course, be considerable if automation in the others produced a major depression; but that we shall consider when we discuss what automation is likely to do to jobs.

How Fast Will Automation Take Effect?

Much depends on how far automation goes. But much also depends on how fast it goes wherever it does go. Even if everything will be automated some day, if the "some day" is 200 or 300 years off, no one is going to worry too much about it, and no one needs to. But if the thing is likely to happen fast, then, even if only part of the economy is likely to be directly affected, the problem may become not only serious but urgent.

How fast *is* it likely to happen? Some people say so fast that it will come upon us like a thief in the night, and we shall hardly have time to draw our breath before we are engulfed in its swirling torrent. In certain industries, they may well be right; in fact, they probably are. For industry as a whole, they are probably unduly alarmed.

Mr. Tait told the Congressional subcommittee that "the rate of progress of automation has its own built-in feedback control, namely, the economics of whether the job that it might perform can pay its way out, for the capital investments in this field are going to be very high. Management can only justify them where the improved product or lowered cost, or combination of both, will repay the heavy initial capital investment over a reasonably short time."[52] Mr. Edwin M. McPherson, of Lester B. Knight and Associates, consultants, told the same subcommittee that "automation becomes feasible only when one or more of the following conditions exist: 1. Present and forecast demand for a product or service exceeds current capacity. 2. Present methods of accomplishing work are over-taxed. 3. Competition is affecting sales volume."[53]

Meier thinks it "unlikely" that even in the industries directly affected, or likely to be directly affected, by automation, "employment in any one industry could be reduced by as much as 50% over a 20-year span, on the assumption that no increase in the demand for these products occurred during that time."[54] On the other hand, the U.A.W. estimates that the American automobile industry, fully automated, could produce as much as now with 200,000 workers, instead of a million. But the assumption of no increase in demand for products of automated industries is surely too pessimistic. Some increase, and probably a substantial one, is almost certain, especially if government, management and labour adopt the right policies to keep purchasing power going up as it should.

These are three main factors which are likely to slow down the adoption of automation, even in those industries which are suited to it.

Cost

The first is cost. This may not be as big a hurdle as it looks. The huge handling and transfer machines required for "Detroit automation" are, as already noted, beyond the reach of any but very large firms. So, no doubt, are the "giant brains". They cost "about a million or more".[55] But there are plenty of smaller computers which are suitable for ordinary business purposes which are cheap enough to make them economic for firms with 500 employees and up. "Prices for purchase of the typical drum systems range from about $50,000 to about $300,000".[56] Very large computers can be rented for $20,000 a month, but smaller ones for $2,000 and $3,000 a month, and it is also possible to lease time on computers.[57] "Nearly all these automatic data-processing machines may be ordered on either a rental, lease with option to purchase, or outright purchase basis."[58] And technical progress may bring down the price of these machines, perhaps rather fast.

None the less, the cost, whether capital or rental, is high enough to make most firms think very carefully before they take the plunge, especially as it will often involve scrapping a considerable existing investment in equipment

which is by no means worn out. This is probably particularly true in Canada, where a great deal of our equipment is the product of the huge new investment of the last ten years.

In some industries, of course, there may be little or no choice. Atomic energy plants just cannot be operated except by automation or something very like it. In the automobile industry, Mr. W. C. Newberg, president of Chrysler's Dodge division, may be right: "Automate or die". The same probably holds for most or all of the industries which are "ripe for automation". Cost what it may, automation will come flooding in. Competition will see to that.

But it does not follow that this will be true of *all* industry. Indeed, the very speed at which automation will probably take place in certain industries may retard its advent in the rest: the industries which have to automate will grab all the available equipment and engineers and technicians. They will be able to pay. The other industries, however much they want to automate, will just have to queue up and wait.

Necessity of Re-thinking and Re-designing

The second big retarding factor is the necessity of re-thinking and re-designing many processes.

This may be very important. Automation is not something you can switch over to at a moment's notice. A steel magnate, impressed by a modern oil refinery or polyethylene plant, can't simply rush back to his own plant and duplicate what he has just seen. If he can duplicate it at all, it will only be after very careful study, which may take years. Steel production uses many automatic controls, but it will probably never be automated till the whole process is re-thought and re-designed. Essentially, Diebold points out, steel making is now a "batch process", just as oil refining used to be.[59] Batch processing of oil simply could not have been automated. The whole thing had to be gone at in a totally different way before automation was possible at all. That has not yet been done for steel, except for a few parts of the process, notably steel casting; and that process had to be completely changed before the thing could be done.

Again, automation is not just putting in a machine to duplicate what a human being does. On the contrary, it may often be putting in a machine to do something a human being could not do at all, or could not do within any practicable time at any practicable expense. Even where the human being can do the thing, a machine which attempts to duplicate his motions may be highly inefficient. Careful study may show that the machine can do the job really efficiently only by *not* duplicating the human being's motions but by doing something totally different.

Sometimes, also, the product has to be re-designed before the making of it can be automated. It simply was not economically feasible to *wire* radio circuits automatically. But, by thinking of what radio circuits were meant to *do,* it was possible to produce circuits that did not have to be wired, but could be plated, stamped, etched, stencilled, sprayed or printed with conductive material. That made automatic production of the circuits possible.[60]

It would be possible to enlarge on this theme at some length. Diebold does. But what has just been said should be enough to show that a company cannot just get automatic machinery to do the job its non-automated factory does now, the way the farmer on the newly electrified farm can put in an electric stove to do the job his old wood range did. The firm may need to have a whole corps of specially trained engineers study its whole operation for years before it can even know whether automation is practicable for it.

It might perhaps be supposed that this would at least not apply to automating an office. The computers are there. They can do all the necessary work. Surely all you have to do is put out the girls and put in the machines?

But in fact this is not so. The Chesapeake and Ohio Railroad plans to have a large computer in operation this spring. It started to look into the matter in 1952. Its offices were then already fairly highly mechanized. But it still found that it needed four years to make the change-over. The C.N.R. expects to take four years to automate its revenue accounting office. The preliminary study will take three years, the actual change-over another year.[61]

Shortage of Engineers and Technicians

The third, and perhaps the most important factor which is likely to make the progress of automation slower than some people imagine is the shortage of the necessary engineers and technicians. This is very serious indeed.

The engineers who are needed are not just any engineers. They are a very new and special kind. They have to have very new and special knowledge. At present, in the United States, there are not nearly enough of them, and the quality of most of the young ones entering industry is not what it should be.[62] It would be rash to assume that Canada is conspicuously better off. And enough new engineers of the required quality cannot be produced overnight. They have to have first class brains, which are not the universal possession of all mankind, and first class training, which takes time, and more so as the universities in many cases find the students deficient in the elementary knowledge of mathematics and other basic subjects on which the specialized training rests.

To make matters worse, some of the best engineers are being, and will continue to be, sucked out of their proper jobs into management positions which pay bigger salaries. Diebold suggests that one way of meeting this

problem (apart from paying the engineers more) is to train management people to understand something about engineering.[63] But this also will take time.

Providing technicians who can look after the new machines is an easier job but by no means easy. It means a lot of re-training for workers who are on the job but have no knowledge of the new technology. It means, so all the experts say, revamping of our educational system, pretty well from top to bottom, to produce people capable of becoming automation technicians. We shall need, again by common consent, a large number of them; and producing them will take time.

Other Retarding Factors

Besides these basic three, there are, of course, other factors which will almost certainly slow the advance of automation. One is human conservatism, or inertia, or stubborn struggle against the inevitable. Long after new methods are available, old ones survive, and on a considerable scale. Hand methods were still used in 1936 in making about a quarter of the long filler cigars made in the United States, though more economical machine methods had been introduced 19 years before.[64] And Diebold says that management consultants often find cases where management hasn't even thought of using automation to solve its problems because it hasn't recognized that the problems exist![65]

For Canada, there may be a special set of retarding factors. Some, perhaps a good deal, of the necessary equipment will have to come from the United States, and the demand for it there may shoot the price to levels we shall find it hard to afford. On the other hand, we may suffer from an even more acute shortage of engineers and technicians than the Americans, because our brightest ones will be lured away by higher salaries and wages in the United States. If we are right in the assumption we often make, that our primary and secondary education, and our undergraduate university education, are, on the average, better than the American, this also may turn out to be a very serious problem.

3

AUTOMATION AND EMPLOYMENT

AMONG the probable effects of automation, none is more important than its effect on employment. This is overwhelmingly important to the labour movement, and hardly less so to governments. If, as some have prophesied, automation produces mass unemployment even worse than we had in the 1930's, the whole social structure might collapse.

What will automation do to jobs?

Clearly, it will destroy some, both skilled and unskilled. A recent study by David G. Osborn at the University of Chicago revealed that "in 12 cases of automation ranging from chocolate refining to railroad traffic control the reduction in employee requirements ranged from 13% to 92% with an average reduction in employment of 63.4%."[66] It must be noted, of course, that this study was based on a very small number of cases, and it would be most unsafe to assume that it applies to all industry.

But even if it applies only to a limited range of industries, it could be a disaster for those who have been doing the jobs concerned. This is a big problem, and it will not solve itself. It calls for a whole series of remedial and preventive measures, which we shall deal with presently. But if those measures are taken, the problem of the displaced workers can be solved, *provided* there are enough other jobs available for them to go to. Will there be?

The answer of business and the economists is yes. Why? First, because automation will mean lower costs of production.

This, of course, is usually the main reason for all mechanization. Mr. Davis, of Ford, told the Congressional subcommittee that "Back in 1900, for example, it took a skilled sheet-metal man, working with handtools, approximately eight hours to shape the upper half of a fuel tank. Today, in our modern stamping operations, it takes approximately 20 seconds. If handtools

were still used to make the upper half of a fuel tank, the labour cost would be approximately $15. Its actual labour cost today is only a few cents. On that same basis, an $1,800 car today would cost approximately $15,000."[67] Mr. Robert W. Burgess, Director, U.S. Bureau of the Census, told the same subcommittee that in the fiscal year 1953, Congress gave the Bureau about $55,000 to tabulate its current population survey, on which the official monthly estimates of employment, unemployment and other characteristics of the labour force are based. In the fiscal year 1955, the first full year this was done with computers, the appropriation was about $28,000, "and a more complex tabulating job was being done."[68]

It is not just a matter of saving labour. Mr. D. G. Mitchell, chairman and president, Sylvania Electric Products, Inc., told the subcommittee that "one of the greatest costs in the electronics industry is . . . sheer waste, a thing that we call in the industry shrinkage. We put dollars worth of raw materials into one of these big picture tubes and if it isn't right when this comes off the last process, the whole thing goes into the scrap pile, except for the glass envelope which we wash out and try to start off again. This shrinkage is the greatest single menace of the industry. The amazing thing is that fully automatic machines don't make shrinkage. The machine stops when you put a bad part or bad process in . . . This is the elimination of waste."[69] Mr. Walter Reuther has pointed out that the automatic machines increase not only the productivity of labour but that of capital: the new machines cost more than those they replace, but "the increase in cost is less than the increase in productivity . . . The investment per unit of production is actually less than that of the replaced machines."[70] Mr. Diebold makes the same point: "A paperpulp mill may operate considerably below the optimum point for a large part of the time. It will only be for a very short period after the regulating devices have been manually set that such an operation will make full use of the material resources that go into it. With automation, it is possible to introduce self-regulating control systems. Instead of operating at the optimum, at the best relationship of all the variables—and in the process industries there may be thousands—for only a few minutes a day, it is going to be possible to operate at optimum for most of the day. Here, obviously, the introduction of automation is not justified by decreases in labour costs; it is justified by increasing the utilization of capital investment, by increasing the utilization of the raw materials. Such automated equipment operates 168 hours a week, rather than 40 hours a week. It makes possible better utilization of capital, higher productivity, a greater rate of return. Call it what you will, what it amounts to is less capital investment per individual unit of output."[71]

Or, as Mr. McPherson sums it up: "Proper sequencing of operations, improved layout, use of electronic controls, or installations of complex equipment normally result in increased productivity, lower reject rates on

finished goods, lower costs, wider acceptance of products, and prompter customer services. Savings are derived from a combination of many elements and not from reduction of labour alone. It is just as important to management to reduce capital tied up in nonproductive inventory as it is to find a method of improving delivery by 24 hours. The savings derived from replacing one clerk with an electronic computer may often be insignificant compared to the advantage gained from developing by machine more reliable data upon which a forecast is dependent."[72]

Lower costs, the argument proceeds, mean lower prices. That, in turn, will mean either that consumers will buy more of the goods concerned, or that they will have more money to spend on other goods and services and so will buy more of those. That, in turn, will mean more employment.

Second, the business-and-economists argument proceeds, automation creates a demand for automatic machines, and that creates employment in designing and making them.

Third, the automatic machines have to be installed, maintained and repaired, and that creates employment.

Fourth, automation may make possible new products or new services. For example, atomic energy would be impossible without it. You just cannot put men inside a reacter. You must operate it by remote feed-back controls and motors. Polyethylene would likewise be impossible without automation. Making it requires such precision in reacting time, temperature and pressures that if you tried to do the thing by hand all you would get would be a useless wax. Many other chemical products and petroleum products depend on split-second reactions which would be impossible without feed-back controls. Many precision products which are reasonably cheap with automation would be fantastically expensive without it. Oil furnaces, and stoves that turn themselves off at just the right moment, would be utterly impracticable without automation. Just think of having to watch the thermometer day and night and switch the furnace on and off by hand! Electronic computers make it possible to provide information which simply could not be produced before fast enough to be of any use. This sort of thing creates employment.

"It would be wrong, I think," said Mr. Marshall G. Munce, vice-president of York Corporation, to the Congressional subcommittee, "to regard the electric light as replacing older forms of lighting, gas or kerosene lamps. What it chiefly replaced was unlighted streets and roads and going to bed at dusk. The automobile did not exactly replace the horse and buggy. What it chiefly replaced was staying at home. It gave the American people mobility, an entirely new way of living."[73] "The important point" about General Electric's big Louisville computer, said Mr. Cordiner, "is that the larger, higher-speed machines enable us to explore new possibilities in the area of business information, and to obtain data that we could not economically obtain before.

Such new and exploratory work now employs about 35 skilled technicians at the Louisville installation."[74] "I think," said Professor Walsh, professor of chemical engineering at Case Institute of Technology, Cleveland, "what we can do in the future is to provide techniques and provide materials for new processes that are not currently operating, and that you might think we are today dreaming about when we consider them. Acetylene would be an excellent raw material for making many new chemicals, and I cannot say all of them. To make acetylene from natural gas we will have to crack it in order of 1.3 seconds. Right now we cannot control the process. It gets away, and we wind up with carbon black and hydrogen . . . A high-speed computer that can figure out in a thousandth of a second what was going to happen under these conditions would have a jump on the process that takes 1.3 seconds. A man just doesn't think that fast. We cannot learn that much about it, and I believe that this is one case . . . whereby automatic plants in the future, with high-speed computers, deciding what the operating conditions should be, are going to become a possibility. I think our future is in new products which will offer more to the economy, will offer employment to more new people, rather than in replacing current operating employees."[75] Mr. Clifton W. Phalen, president, Michigan Bell Telephone Company, reminded the Congressional subcommittee that mechanization in the telephone industry had made available a whole host of new services: "telephone service for ships and automobiles, service to foreign countries, teletypewriter-exchange service, dial switchboards for individual customers, intercommunication systems and wiring plans, automatic answering devices, time and weather service, conference service, picture-transmission service, radio and television network service, speaker phones—those are the kind you use without taking the receiver off the hook—volume control telephones, and school-to-home services for convalescing children."[76] Dr. A. V. Astin, Director, National Bureau of Standards (U.S.), told the subcommittee that "approximately half of our labour force is now engaged in producing or marketing materials or devices that were generally unheard of 50 years ago . . . Our experience with (the new automatic computing) machines shows that they are not used primarily to do old work with fewer people. Instead, we are tackling the important new problems with the same or even more people."[77] He added that a special committee to investigate mechanizing patent search operations found that without mechanization the Patent Office staff simply could not keep up with the flood of applications, and that mechanization of the routine aspects of the patent search process was essential if the patent system was to continue to make its contribution to the expanding economy.[78]

For proof of the validity of their arguments, business and the economists point to history. The whole process of mechanization ever since the Industrial Revolution began has meant constant displacement of labour. But are there fewer people employed now than at the end of the 18th century? No. There are far more, and at a far higher standard of living. Mechanization in the last

decade has been going ahead faster than ever before. Are there fewer people employed now than there were ten years ago? No. More, and at a higher standard of living.

The automobile knocked out the carriage and wagon industries, and displaced the people who worked in them. But it created a far bigger industry, with far more workers, and a whole string of industries supplying materials and parts to the automobile industry itself. It created the whole service station and garage industry, and forced the building of an enormous network of roads. It gave a tremendous fillip to oil and rubber, and what might be summed up as the vacation industries. The moving picture knocked out a lot of small theatres, and displaced the people who worked in them. But it created a far bigger industry, with far more workers.

Undoubtedly the design and manufacture of automatic machines will create some employment. But how much, especially if the automatic machine industry itself is automated?

Diebold, who makes no bones about calling automation the Second Industrial Revolution, says that "the first, the foremost and the most startling" difference between it and the First Revolution "lies in the fact that automation has created new jobs before its machines have replaced many old jobs. We are all aware that technological progress always produces these results. What we worry about is the time lag during which men have no work between the old and the new jobs. That is what happened, in part, during the First Industrial Revolution. This time a new pattern seems to be developing. Automation has already produced a new industry in America. There are more than 1,000 companies engaged wholly or partly in the manufacture of automation equipment. Their aggregate output last year totalled more than $3 billion. And they are one of the fastest growing industries in America."[79]

But from 1947 to the first half of 1955, production in the American electrical manufacturing industry rose 87%, while production workers rose 14% and non-production workers 40%.[80] Electronics output in the United States in 1952 was 275% higher than in 1947, but was produced by only 40% more workers.[81] The Labour Department study added: "Output per man-hour may rise even faster during the next years as a result of improvements in manufacturing techniques. . . . These trends toward 'automation' may result in the greatest reduction in unit man-hours in the industry's history during the next few years".

Comparing the electrical machinery industry as a whole in the first half of 1955 with 1953, the total number of employees was down 9% and the number of production workers 13%, while non-production workers were *up* 1%. (But the drop in production workers was 119,500, while the rise in non-production workers was only 2,300.) In electrical generating equipment and

industrial apparatus, etc., total workers were down 8%, production workers 11%, and non-production workers 2%. In electrical appliances, total workers were down 9%, production workers 13%, while non-production workers were *up* 9%. In electric lamps, total workers and production workers were both down 7%, while the number of non-production workers was unchanged. In communication equipment, total workers were down 11%, production workers 16%, while non-production workers were up 3%.[82] In the first seven months of 1955, in the American communication equipment and related products industries, the total number of employees was 11.4% below the same period in 1953, and the number of production workers was 16.7% down.[83]

Undoubtedly the automatic machines will need installation, maintenance and repair men. But how many?

Undoubtedly automation may make possible new products and a demand for new services, and that would create employment. But how much?

Will it do what the automobile or the movie did? Professor Buckingham thinks not: "Any loss of purchasing power due to a lower wage bill may not be offset by expenditures induced in other industries much as accompanied earlier advances in mechanization."[84] But most of the management witnesses before the Congressional subcommittee seemed confident that he was wrong. Mr. Cordiner, for example, said: "In General Electric, 70,000 of our employees work on new types of products we did not make in 1939. such as television, jet engines, chemical products and atomic energy . . . The computer, extending man's mental capacities beyond anything we can imagine, will create fantastic increases in human knowledge, and thus vastly increase the number of things we can make and enjoy. Based on our experience with these machines . . . it may well be that the computer-derived technologies will be a major source of new employment in the 1960's and 1970's and they will keep us perpetually short of manpower to take advantage of our opportunities."[85]

Undoubtedly, also, automation means lower costs of production. But that does not necessarily mean lower prices. In industries dominated by one or a few firms which can set prices pretty much where they please, it may not mean lower prices at all, just higher profits. These will go mainly to the well-to-do, who cannot greatly increase their spending on consumers' goods and services, but only their savings. What happens then?

Long-run Trends, Production and Employment, Agriculture

Mechanization, even without automation, has undoubtedly cut down employment in agriculture (Chart 1). In 1931, we had 1,203,000 people with jobs in agriculture: farmers, farm labourers, unpaid family workers. In 1955 we had 818,000. And that is not the most striking contrast. For the number of people with jobs in agriculture rose steadily from 1931 until 1939, when

it reached 1,364,000. Then it fell for four successive years, then went up a little for three, then fell steadily again for seven, went up slightly for one, then started down again. From the 1939 peak to 1955, the drop has been 546,000, or 40%. In the first three months of 1956, there has been a further drop of almost 10% from the same period of 1955.

But perhaps this is because we have been producing less on our farms? Not a bit of it. On the contrary, we are producing a great deal more. Even in 1954, a year of poor crops, with about a third fewer workers than in 1935, we produced about 20% more goods. In 1952, with 31% fewer workers than in 1935, we produced almost 75% more goods.

Mining and Manufacturing

The same sort of thing has been happening in mining since 1948 (Chart 2). Employment has not actually fallen, except in 1953 and 1954, but it has lagged markedly behind production. The employment index does not, of course, make any allowance for short time or overtime, but it is unlikely that any such allowance would materially affect the trend. In 1955, with only about 17% more workers than in 1948, our mining industries produced over 98% more goods.

Similarly with manufacturing since 1946 (Chart 3). Employment has not actually fallen in any year except 1954, but it has certainly failed to keep pace with production. In 1955, with only about 20% more workers, manufacturing as a whole produced almost 42% more goods than in 1946. In durable goods, with 29% more workers, the plants produced about 58% more goods, and in non-durables, with 11% more workers, about 31% more goods (Chart 3). Of course something depends on what base year we take, but the general trend is unmistakable.

Figures for particular industries are less satisfactory than those for large groups, since factors peculiar to each industry can account for considerable changes, and a base year which may be all right for a large group may be all wrong for a particular industry within that group.

Particular Manufacturing Industries

None the less, the figures for certain manufacturing industries are striking.

In pulp and paper, in 1955, we produced about 47% more goods with only about 30% more workers than in 1946. In comparison with 1950 or 1951, however, the increase in production has just about matched the increase in employment (Chart 4).

In wood products, in 1955, we produced about 46% more goods than in 1946 with only about 20% more workers.

In electrical apparatus and supplies, in 1955 we produced about 116% more goods than in 1946 with only about 72% more workers.

In primary iron and steel, in 1955, we produced about 82% more goods than in 1946 with only about 34% more workers.

In motor vehicles, in 1955, we produced about 144% more goods than in 1946 with only about 56% more workers. In this case, 1947 would probably be a better base year, since 1946 showed a very sharp dip in production with only slight drop in employment. Comparing 1955 with 1947, we find an increase of about 74% in production while workers increased about 34%.

In textiles, production rose from 1946 to 1950; then fell in 1951, 1952 and 1954, with only a slight rise in 1953; then rose steeply in 1955, but only to a point still far below the 1950 peak. In 1955, the industry produced about 15% more goods than in 1946, with about 5% *fewer* workers. In comparison with 1947, it produced about 7% more goods with about 11% *fewer* workers. Compared with 1950, it produced about 13% *less* goods with about 17% fewer workers (Chart 4).

None of these figures is altogether satisfactory. For one thing, the employment index does not, of course, take account of hours worked. Sometimes, when output falls off, the firms concerned do not lay people off, but just put them on short time; and when output picks up again, they do not take on extra people, they just put the existing staff back on full time, or work them a bit of overtime. In textiles, in 1951, production fell slightly, while employment rose; but average hours worked fell from 43.3 to 41.5. In 1955, production rose more than employment; but actual hours worked also rose, from 41.0 to 42.5.[86] In primary iron and steel, in 1954, production fell much more steeply than employment, but hours also fell from 40.6 to 39.9; in 1955, on the other hand, production rose steeply, while employment rose only very moderately, but hours also rose from 39.9 to 40.7.[87] In motor vehicles, in 1954, production dropped steeply, while employment dropped only moderately, but hours worked also dropped from 40.8 to 39.3; in 1955, on the other hand, production rose much faster than employment, but hours worked also rose from 39.3 to 41.6.

For another thing, man-hours worked are, in some cases, one of the component parts of the index of production, so that if man-hours worked are falling, or even not rising as fast as the other components, a rise in the index understates the real increase in production.

So the "widening gap" between production and employment shown in the charts for agriculture, mining, manufacturing as a whole, durables and non-durables, and particular industries, is only an approximation. But the trend, for these industries and groups, is so marked that even if there is a substantial margin of error the broad fact remains: in these industries and

groups of industries employment is not, on the whole, increasing as fast as production. There is a "widening gap", perhaps narrower, perhaps wider than appears; perhaps not widening as fast as the charts suggest, perhaps widening faster; but unmistakably there.

The "Gap" and Automation

Mr. Weinberg's first form of automation, automatic machinery of the traditional type, is certainly responsible for part of this widening gap. "Detroit automation", automatic control systems and electronic computers, can have had little to do with it, except perhaps in the last year or so. There are too few examples of them in this country, and they have appeared too recently, to have had any noticeable effect on the longer period. So, broadly speaking, the "gap" is the result of conventional mechanization.

The point of the charts, therefore, is not "look what automation's done!" but "look what's been happening even without automation!" "If this shall be done in the green tree, what shall be done in the dry"? In more formal language: if traditional mechanization has produced this effect, what will automation do, piled on top of traditional mechanization?

Business and the economists, however, will decline to be frightened by our charts. After all, the figures cover only agriculture, mining and manufacturing, which together account for only about 42% of our labour force and about 37% of our wage and salary earners. Most of our employment is outside these industries, and the "widening gap" in them is just another way of saying that productivity in them is rising.

In agriculture, it simply means that we can now produce all the farm products we want and can sell (indeed, rather more than we can sell at prevailing world prices!) with half the proportion of our labour force we used to need for it (15% in 1955 against 30% from 1935 to 1939) and with 546,000 fewer farm workers than before the war. In other words, we have over half a million more workers to produce other goods and services we want. What's wrong with that? To insist that we should continue to employ in agriculture the same number of people as we did 15 or 25 years ago, let alone the same proportion of the labour force, would be just silly, an inexcusable waste of manpower. One of the marks of the progress of civilization is the ability to produce more and more food with a smaller and smaller proportion, and even a smaller and smaller absolute number, of people on the land.

In 1953, we had 858,000 people with jobs in agriculture, or about 16.4% of the total with jobs, against 25.3% in 1946. If we had still needed the same percentage as in 1946, we should have had to have another 469,000 farmers and farm workers.

Number Rises — Proportion Drops

In mining and manufacturing, the situation is, of course, not quite the same. The absolute number of people employed in mines or factories has not gone down. On the contrary, it has gone up. But the proportion both of the non-agricultural labour force (people with jobs) and of non-agricultural wage and salary earners in these industries certainly has gone down. In 1946, mining and manufacturing together accounted for about 37.1% of the non-agricultural labour force and about 40.0% of the non-agricultural wage and salary earners.[88] In 1953, they accounted for 33.7% of the non-agricultural labour force (people with jobs), and 36.4% of the non-agricultural wage and salary earners. We can now produce far more mineral and manufacturing products than in 1946 with a much smaller proportion of our working force. If, in 1953, we had still needed the same proportion of total wage and salary earners for these industries as in 1946, we should have had to have another 139.000 of them. To insist that in 1953 we ought still to have been employing in mines and factories that extra 139,000 would, again, be just silly, an inexcusable waste of manpower. One of the marks of the progress of civilization is the ability to produce more and more *things* (as distinct from services) with a smaller and smaller proportion of total available manpower. It leaves us with just that many more people available to provide various types of services, or with just that much extra time to enjoy ourselves.

Putting it another way, the thing will work out all right, as far as employment is concerned, if (1) the workers or potential workers who are now superfluous in agriculture, mining and manufacturing (and perhaps other industries, for which we have no satisfactory production indices) find jobs in other industries; or if (2) we work everybody shorter hours; or if (3) we keep our young people longer in school and college and let our old people retire sooner; or if (4) we do enough of all these things to provide employment for those who want it.

In fact, we have been doing a bit of all these things.

In 1946, trade, finance and services together took 40.5% of our non-agricultural wage and salary earners. In 1953, they took 42.7%. If they had taken only the old 40.5%, they would have provided 87,000 fewer jobs.

Obviously that did not take up more than a small proportion of the extra workers made available by the shrinkage in agricultural employment and the relative shrinkage (in relation to production) in mining and manufacturing employment.

Shorter Work Week

But we have also been shortening the work week. Even as late as October 1, 1949, only 25.1% of plant employees in manufacturing were working 40

hours per week or less, and 26.9% were working 48 or more per week. By April 1, 1954 (the nearest date for which figures are available which can be taken as representative of 1953 as a whole), 52.8% were working 40 hours or less, and only 11.4% 48 or more.[89] At October 1, 1949, the percentage of non-office employees in retail trade working 40 hours or less was only 30.1; by April 1, 1954, it was 48.8.[90] During the same period, the railways' non-operating employees got their work week cut from 48 hours to 40; and the same sort of thing was happening in various other industries.

More Paid Statutory Holidays

We have also been shortening working time by providing for more statutory holidays with pay and more and longer vacations. At October 1, 1949, only 32.3% of plant employees in manufacturing had eight or more paid statutory holidays; by April 1, 1954, the percentage was 52.0.[91]. At October 1, 1949, only 81.0% of these employees were entitled to two weeks' vacation with pay; by April 1, 1954, the percentage had grown to 92.0. In 1949, only 16.8% got two weeks after two years' service or less; by 1954, the percentage was 25.8. The percentage entitled to three weeks after various periods of service grew from 30.4 to 53.6.[92]

More Schooling — Earlier Retirement

We have also been keeping our young people longer in school and college. In 1946, 12.7% of our labour force was in the 14-19 age group; by 1953, it was 10.0, though the proportion of such young people in the total population certainly was not dropping at any such rate.

We have also been retiring our older workers earlier. In 1946, 4.7% of our labour force was in the 65 and over group. By 1953, this had dropped to just under 4.0; and again the proportion of this group in the total population certainly was not dropping at any such rate.[93]

What does it all add up to? In 1946, we had 143,000 "persons without jobs and seeking work" out of a total of 3,300,000 wage and salary earners plus such jobless. In other words, 4.3% of the supply in the labour market was unemployed (taking the DBS Labour Force figures). In 1953, we had 137,000 "persons without jobs and seeking work" in a total labour market of 4,103,000 or 3.3%. All told, one way and another, we had managed to provide jobs for all those who had been displaced by technological progress, and then some.

It may be objected that 1946 was an abnormal year. Very well: take 1947 and 1953. In 1947, we had 98,000 people without jobs and seeking work, or just under 2.9% of the labour supply. On this showing, in 1953 we hadn't quite absorbed all the displaced workers, but very nearly. Comparison with 1948 yields about the same result.

So far so good, and not too much to worry about.

1954-56

But that was 1953. What about 1954 and 1955?

1954 is perhaps a hardly fair year to take for comparison. It can be argued that it was "abnormal", a year of "temporary readjustment", "pause that refreshes", or what not. But such arguments do not apply to 1955. In 1955, production was consistently above 1953, the previous peak year. What about employment and unemployment?

The DBS estimates that the Gross National Product for 1955 was about 6% above 1953.[94] As prices have remained pretty stable, this is approximately the increase in "real" terms (goods and services, not just money). The number of people with jobs in 1955 averaged about 1.5% above 1953, and the number of wage and salary earners was up about 6%.[95]

For the year as a whole, therefore, employment did not keep pace with the increase in production, though the situation in this respect was much better at the end of the year than at the beginning. It would be unsafe to draw any very definite conclusions about a widening gap between production and employment generally for the near future.

But this is not the whole story. What happened to *unemployment?* In 1953, as we have seen, people without jobs and seeking work averaged 137,000, or 3.3% of the supply in the labour market. In 1955, they averaged 230,000, or 5.3% of the supply in the labour market. In other words, it looks as if the increase in the number of jobs at salaries or wages had certainly not kept pace with the increase in the number of people available to take such jobs. In plain language, the increase in workers was bigger than the increase in jobs, for the year as a whole.

But again it would be unsafe to draw any very definite conclusions from the annual averages for the two years. For while in the earlier months of 1955, unemployment was much heavier than in the corresponding months of 1953 (Table 1), in the summer and early fall the percentages were much closer, in November they were identical, and in December 1955 the percentage was actually a little lower than in December 1953. On the other hand, November and December 1953 were both bad months, compared with 1952: the recession of 1954 was already casting its shadow before. December 1955, compared with December 1952, shows a percentage of unemployment about one-third worse. January 1956 was about 38% worse than January 1953; February 1956 was almost 56% worse than February 1953; and March 1956 was over 52% worse than March 1953.

Seasonally adjusted data in the February 1956 and later numbers of the *Canadian Statistical Review* reinforce these conclusions. The recession of

1954 began to cast its shadow as early as the summer of 1953; and the seasonally adjusted averages of persons without jobs and seeking work (Table 1A) make an even worse showing than the unadjusted figures.

Perhaps, so far, the verdict must be the Scottish "not proven", or the Irish "not guilty, but don't do it again". Perhaps, so far, we cannot say positively that employment is continuously failing to keep up either with the increase in production as a whole or with the increase in the number of workers. But, very clearly, it may be doing either or both, and the situation will bear careful watching. Certainly it gives no ground for complacency, or for assuming that everything will come out right automatically, without anyone taking thought about it, or action on it.

Jobs and Workers, 1955 and 1961

Some people think there is no need to worry about whether we shall have enough jobs to go round, in the next decade or so; what we really have to worry about is whether we shall have enough workers to go round. If we are going to keep up our standard of living, let alone increase it, are we going to have enough workers to do it, without automation?

Several of the management witnesses before the Congressional subcommittee said no, emphatically, as far as the United States was concerned.

Mr. D. G. Mitchell, citing the magazine *Factory Management and Maintenance,* predicted a 1975 Gross National Product of $850 billion, and a working force of 82 million, adding: "They point out that if the present rate of automation continues, every available worker will have to be putting in 40 hours a week, in order to keep raising our standard of living at the rate it is being increased now. The entire nation's long-term goal of a shorter work week would be impossible. If Mr. Reuther wants the 32-hour work week . . . then we had better get on the ball and speed up automation because if we don't, he cannot have it. A 32-hour work week . . . would require an estimated 105 million persons, and that large a force will not exist."[96]

Mr. Cordiner said: "According to our company's estimates, and they are in line with the estimates of your committee's staff, the United States will require about 40% more goods and services by 1956, with only 14% more people in the labour force. To produce 40% more goods and services with only 14% more people, either everyone must work harder and longer, which is neither a realistic nor a good solution, or industry must be encouraged to invest in more productive machinery and methods. Faster progress in the newer field of automation seems to us to be the only available solution to this problem, particularly in situations where we have exhausted the known economic possibilities in the more familiar field of simple mechanization. From all that we can foresee, it appears that there will be a shortage of men

and women to fill the work opportunities in the coming decade. After 1965, when the proportion of labour force to the total population increases, some feel that there may be a trend toward the shorter work week. But our feeling is that the demand for goods may rise so fast in the 1970's that we (will) still be hard put to produce enough goods to satisfy the market on a 40-hour basis, and the American public will choose more goods in preference to a shorter work week."[97]

Dr. Brunetti protested energetically against "the tendency to consider today's workload in terms of tomorrow's machines . . . Certainly we would not consider doing today's work with machines we had 20 years ago. How could we ever have achieved the standard of living which we enjoy today if we had retained the tools of 20 years ago? Why, then, do we assume a static workload when we consider the effects of automation on the labour force? . . . Now to see what using the capacity of tomorrow's machines with relation to today's unemployment does to our figures, let us consider the gross national product of our country. In these terms, our workload today exceeds $370 billion. I believe the latest figures published were $392 billion. This work we must do with a labour force of 65 million people. This means that each one of us in the labour force must produce about $5.700 worth of goods or services, to contribute to the gross national product of the nation. In 1940, we had a gross national product of $101 billion and a labour force of 54 million people. Each member of the labour force were (sic) producing about $1,900 worth of goods and services. Let us go back to that time and assume that some forward-looking exponent of automation had described the machinery which we had available today, and which enables us easily to produce $5,700 per worker, per member of the labour force. Noting this effect on the 1940 workload, we would have predicted a displacement of about 36 million people. However, we must remember that the dollar was worth more at that time, so we recomputed the figures, and we come out with 18 million people. No matter how you compute it, if you had used today's equipment in terms of the 1940 workload, we would certainly have predicted a depression at that time.

"Let's consider it in terms of today. Suppose we had frozen our tools at the 1940 design, and attempted to turn out today's workload. . . . We would need a labour force of 195 million people, three times the available labour force in the United States today. Now an analogous situation exists when we attempt to consider today's workload in terms of tomorrow's machinery."[98]

Mr. Peter F. Drucker predicts an even smaller 1965 labour force than Mr. Cordiner: an increase of only six per cent from now, against Mr. Cordiner's 14, and insists that over the next 20 years there will be, in the United States, more jobs than workers.[99]

Table 1

Unemployment, 1952, 1953, 1955, 1956

	1956			1955			1953			1952		
	Labour Market	Persons without jobs and seeking work	%	Labour Market	Persons without jobs and seeking work	%	Labour Market	Persons without jobs and seeking work	%	Labour Market	Persons without jobs and seeking work	%
Jan.	4393	286	6.5	4205	363	8.6	4014	189	4.7			
Feb.	4411	308	7.0	4225	379	9.0	3999	181	4.5			
March	4413	295	6.7	4227	401	9.5	3982	174	4.4	3930	209	5.3
April		257		4222	327	7.7	4030	167	4.1			
May				4272	213	5.0	4060	115	2.8	3997	106	2.7
June				4449	157	3.5	4116	91	2.2			
July				4376	150	3.4	4174	91	2.2			
Aug.				4438	131	3.0	4215	93	2.2	4044	86	2.1
Sept.				4402	138	3.1	4207	85	2.0			
Oct.				4421	142	3.2	4150	112	2.7			
Nov.				4413	162	3.7	4156	153	3.7	4081	114	2.8
Dec.				4430	200	4.5	4127	192	4.7	4049	132	3.3

Source: D.B.S. *The Labour Force.*

Table 1A

Unemployment (Seasonally Adjusted), 1952, 1953, 1955, 1956

	1956			1955			1953			1952		
	Labour Market	Persons without jobs and seeking work	%	Labour Market	Persons without jobs and seeking work	%	Labour Market	Persons without jobs and seeking work	%	Labour Market	Persons without jobs and seeking work	%
Jan.	4301	201	4.7	4094	255	6.2	3943	131	3.3			
Feb.	4304	204	5.0	4090	251	6.1	3932	120	3.1	3845	137	3.6
March				4102	263	6.4	3927	115	2.9			
April				4193	238	5.7	3971	122	3.1			
May				4191	236	5.6	3981	132	3.3	3916	130	3.3
June				4181	226	5.4	3978	129	3.2			
July				4342	222	5.1	4052	135	3.3			
Aug.				4328	208	4.8	4064	147	3.6	3922	138	3.5
Sept.				4350	230	5.3	4057	140	3.5			
Oct.				4324	209	4.8	4020	164	4.1			
Nov.				4301	186	4.3	4030	174	4.3	3948	128	3.2
Dec.				4313	198	4.6	4044	188	4.6	3949	129	3.3

Note: Data on "paid workers, non-agricultural", available only on a quarterly basis; hence, "labour market" figures are approximate.

Source: D.B.S. *Statistical Review.*

This approach to the problem confidently assumes that the GNP, or the national "work load", is going to go on increasing as fast as it has been. But Dr. Nourse sounded a note of caution: "I strongly suspect that we have already built up at many spots a productive capacity in excess of the absorptive capacity of the forthcoming market under city and country income patterns that have been provided, and employment patterns that will result from this automated operation. . . . We have not yet demonstrated our ability to adjust the actual market of 1956-7, and later years, to the productivity of the production lines we have already modernized. They have not yet come to full production, but as they do, we see incipient unemployment appearing."[100] He added, in a footnote: "It is well to remember that not all years are equally propitious for the reabsorption of workers displaced by technological changes, nor is the situation the same in all industries. Several witnesses in these hearings have presented evidence that they have created new jobs faster than old jobs have been displaced by technological changes. This is conspicuously true in the telephone, television, and other branches of the electric and electronics industries, where demand has been very elastic. It has not been true in farming and in railroading, where demand has been stationary or declining—even in the very prosperous years we have been experiencing.

"Nor can the problem be left entirely to the curative or preventive powers of population growth, which is one of the chief reliances of the economic faith healers. The notion that the growth of total population in the next decade will far outstrip the growth of the labour force, which was launched by a writer of popular economics, is contradicted by recent analyses of the U.S. Bureau of the Census." [101]

And again: "When businessmen or others say that technological progress . . . takes care of its own economic problems, they invoke a simple logic of the free-enterprise economy. The entrepreneur seeks profit by adopting a device for raising efficiency. This lowers cost. Price falls proportionately and thus broadens the market. This restores the number of jobs or even increases them and raises the level of living or real incomes. This comfortable formula presupposes a state of complete and perfect competition in a quite simple economic environment with great mobility of labour, both geographical and occupational. But these are not the conditions of today's industrial society, with large corporations and administered prices; with large unions and complicated term contracts covering wages, working conditions, and 'security'; with complex tax structures, credit systems, and extensive Government employment and procurement. The smooth and beneficent assimilation of sharp and rapid technological change has to be effectuated through intelligent and even generous policies painstakingly arrived at by administrative agencies, private and public."[102]

What about Canada: our future labour force and future GNP? Guessing at either is, of course, decidedly "iffy", to use Mr. Roosevelt's valuable word.

Guessing how big our labour force will be five, 10 or 15 years from now is not at all easy, for several reasons.

First, we don't know what the total population will be. That will depend on the birth rate, and on immigration and emigration. Canadian Economic Research Associates, of Toronto, have made four projections, for the years 1960, 1965, 1970 and 1975. The first assumes "upper values of fertility rates and 30,000 net immigration per annum," the second " lower fertility rates and 100,000 net immigration per annum", the third "upper values of fertility rates and 100,000 net immigration per annum", and the fourth "medium values of fertility rates and 100,000 net immigration per annum". For 1960, the estimated total population ranges from 17,303,500 to 17,701,300; for 1965 from 19,040,000 to 19,925,600; for 1970 from 20,933,100 to 22,353,400; for 1975 from 23,153,800 to 25,179,700. But the assumptions are important. Either fertility rates or immigration might fail to conform to them, and so throw the whole thing out.

Then there's the age composition of the population. Here, given certain estimates for the total, it is possible to be fairly definite. The age group from which the labour force is now drawn is the 14 and over group, and mainly the 14 to 64 group. The CERA projections unfortunately don't give the 14-64 group, but they do give 15-64, which will serve well enough for the purpose, especially as the age of entry into the labour force is undoubtedly rising and will probably rise further. The CERA projections show this 15-64 group as from 59.3% to 59.7% of the total population in 1960, from 59.3% to 60.3% for 1965, from 59.8% to 61.4% for 1970, and from 59.7% to 62.1% for 1975.

There is, of course, the possibility that the age of entry will rise and the age of withdrawal fall; so it is worth while also to look at the 20-59 group. The CERA projections show this as from 48.2% to 48.7% of the total in 1960, from 47.1% to 48.2% in 1965; from 46.9% to 48.7% in 1970, and from 46.8% to 49.2% in 1975.

In short, it looks as if, on these assumptions, we should have, as the years pass, a rather larger proportion of the population in the labour force age group than we have now.

There is the question of what proportion of this group actually goes into the labour force: the "participation rate". This has been falling, but it seems most unlikely that it will go on falling. But we have no idea of what will happen to the ages of entry or withdrawal, or what the participation of women will be.

Table 2

Participation Rates and Labour Force Estimates by Age and Sex, 1961

			Estimate based on June 1, 1955 Participation Rates		Estimate based on Extrapolation of 1946-55 Participation Rates	
		Population 14 years & over	Part. Rates	Labour Force	Part. Rates	Labour Force
Male & Female	Total	12,135		6,145		5,893
	14-19	1,784	36.3	647	30.6	546
	20-64	9,005	58.5	5,265	57.5	5,174
	65 & over	1,346	17.3	233	12.9	173
Male	Total	6,096		4,746		4,533
	14-19	911	42.9	391	35.6	324
	20-64	4,531	91.5	4,146	89.4	4,051
	65 & over	654	32.0	209	24.2	158
Female	Total	6,039		1,399		1,360
	14-19	873	29.3	256	25.4	222
	20-64	4,474	25.0	1,119	25.1	1,123
	65 & over	692	3.5	24	2.2	15

Besides, both future population and future labour force will depend partly on the level of economic activity.

Assuming that the population trends of the last few years continue, and that the participation rate stays the same as at June 1, 1955, our 1961 labour force will be about 6,145,000 or 9.4% above 1955. Assuming the same population trends, and an extrapolation of 1946-55 participation rates, our 1961 labour force will be 5,893,000 or about 5% above 1955 (Table 2).

So much for the workers. What about the jobs?

From 1946 to 1955, Gross National Product in constant dollars rose about 41%. If it goes on rising at the same rate, the 1961 total will be about 19.5% above 1955.

If productivity per member of the labour force rises 9.2% over the six years (a very moderate increase, just a trifle over 1.5% per year on the average), and the labour force rises 9.4%, total GNP will rise exactly the 19.5% noted above.

But everyone agrees that automation will increase productivity.

If productivity per member of the labour force increased by half, if it were 13.8% over the six years instead of 9.2%, and the labour force itself increased by 9.4%, that would mean a 1961 total GNP 24.5% above 1955. But if, for some reason, GNP increased only 19.5%, and productivity 13.8%, then the total 1961 GNP would fall about 4% short of employing a labour force of 6,145,000. The shortage would be about 245,000 jobs.

On the other hand, if productivity per member of the labour force increased 13.8%, and the labour force itself only 5%, total GNP would increase 19.5%, and there would be no shortage at all.

All this, of course, assumes either that there will be no further reduction in hours of work, or that any reduction there is will be fully offset by increased productivity per man-hour. Both assumptions are unlikely. The calculations also take no account of existing unemployment or changes in the ratio of wage and salary earners to total labour force. But they are enough to show that unless the increase in GNP is big enough to keep pace with increases in both the labour force and productivity, unemployment on a considerable scale could result.

Actually, it will be very surprising if automation does not raise productivity much more than we have suggested above. "In the University of Chicago study referred to above," says Professor Buckingham, "productivity increases in 12 cases of automation ranged from 14% to 1,320% in a case of office automation with the average for all cases being 382%."[103] Again it must be emphasized that this study was based on only a small number of cases, and these percentages would not necessarily apply even to all automated industries, let alone all industries. But even if only a much lower percentage increase applied to only 25% of all industries, the average increase in productivity for the whole economy might be formidable.

More Leisure?

This looks terrifying. But it need not be. There are several things we can do about it.

First, if we are content to go on increasing GNP only as fast as we have been doing, we can take steps to cut the labour force to the extent necessary to do just that. We can reduce hours of work. We can increase the number of statutory holidays, and lengthen vacations. We can keep youngsters longer in school and college, and retire oldsters sooner. If our productivity rises steeply as a result of automation, and we want only a modest annual rise in our standard of living, this is the kind of thing we shall have to do. We shall have to cut our labour force cloth to suit our income coat.

To some extent, we shall probably do these things, though probably not entirely for that reason. Most of us want more education for our children and more leisure for ourselves. Some of us would like to retire earlier (provided we had a secure income, of course). The requirements of automation itself may work in the same direction: older workers may be hard to re-train for the new jobs, and new workers will certainly need a lot more education than they're getting now, on the average.

But the probability is that we shall not take all our gain in productivity in such forms. It is notorious that some people who retire even at 65 or 70

don't know what to do with themselves, and die of sheer boredom. Some of the rest of us, if we suddenly found ourselves with a lot more leisure, might find the time hanging heavy on our hands. There is room for a good deal of education in the proper use of leisure. However, we are not likely to find these problems too difficult, because automation will probably not come upon us at breakneck speed (except in some industries), and the employers will see to it that shorter hours, more education, and extra pensions (industrial or government) are not handed to workers on a platter.

The Shorter Work Week

It is widely assumed, in the United States at any rate, that automation must lead to a drastic shortening of the work week; that this will be essential to absorb the large numbers of workers displaced by the new machines. But this assumption is dubious. Even in highly automated industries there may be no reduction in employment. If the lower cost of production results in lower prices, and demand for the product is elastic, sales may shoot up and employment in the industry may remain stable or even rise. Even if the prices do not fall, but merely remain the same while other prices are going up, the same results may follow, especially if the quality of the product improves, so that the consumer is actually getting more for his dollar. The Ford Motor Company told the Congressional subcommittee that its non-defence employment in 1954 was greater than in 1950: total man-hours worked were 14% higher.[104] General Electric told the same body that "The housewife buying many of our consumer products will find a lower price tag now than she did in 1950, even though the products have improved", and gave half a dozen examples. It also said that since 1939, the weighted average of General Electric prices had gone up only 57% while the price of all commodities except farm and food had gone up 102%; and employment at General Electric had increased six times as fast as in the economy as a whole.[105] These figures may be open to criticism; we do not know. But even if they were wholly wrong, this is the sort of thing that *could* happen. In such a situation, it would not be necessary to shorten the work week to take up the slack in employment, because there would not be a slack in employment. (There might, of course, be considerable reductions in particular kinds of employment, and increases in other kinds, within the total; but that is a different problem, which we shall come to presently.)

On the other hand, there are industries the demand for whose products is inelastic: even drastic price cuts would produce no appreciable increase in sales. Automation would severely reduce total employment in these industries unless the work week were shortened to spread the available work over the same number of workers as before, or at least over a larger number than would otherwise be employed in the new circumstances. If there were plenty of jobs at good wages in other industries in the locality, many of the dis-

placed workers would probably go to those, and the necessity of shortening hours to spread work in the first lot of industries would be that much less. If there were few, or no, jobs at good wages available in other industries in the locality, then shortening the work week would be an obvious way of meeting the situation. It would also be perfectly feasible, because the increase in productivity would put the enterprises concerned in a position to shorten the work week without reduction in take-home pay.

If, either from necessity or from deliberate choice, hours are drastically shortened in automated industries, workers in the non-automated industries will undoubtedly press for the same shortening, and, if they are well organized, will get at least part of what they demand. The shorter hours and higher hourly rates will spread out from the automated industries to the non-automated. This will raise costs in the non-automated industries. They will have no extra productivity from automation to enable them to bear these extra costs. They will, therefore, have to cut their profits or raise their prices.

If they cut their profits and leave their prices alone, demand for their products will remain stable, and employment in their plants will rise (because, with the shorter work week, they will need more employees to produce the same output).

If, as is more likely, they raise their prices, demand for their products will fall. If it does not fall much, then total employment in these industries may be greater than it was before the whole performance began. But demand could fall so much that total employment in these industries would be less.

Or More Goods and Services?

But we shall probably not be content to go on increasing our GNP only as fast as we have been doing. We shall probably want to increase it faster, perhaps much faster. We shall probably want not only more education, more leisure and earlier retirement, but also a lot more goods and a great many more services. There are still a great many people, even in Canada, with the second highest standard of living in the world, who are going short of things we like to think of as commonplaces: hundreds of thousands of extra dwellings to catch up with our accumulated housing backlog; hundreds of thousands of houses needing major repairs, or running water, or baths, or toilets, or hot water, or electric or gas stoves, or mechanical refrigerators, or washing machines, or vacuum cleaners, or telephones, or furnaces, or automobiles; more schools, more hospitals, more parks, more roads.

We also need more services: more teachers, more doctors, more nurses, more dentists. Given more leisure, and more money, most of us could take a lot more travel.

Most of us, even in Canada, are a long way from having all the things, let alone all the services, we want. We are a long way from having even all the modern conveniences that already exist, let alone the new ones automation and other technological progress may make possible. We are a long way from being as healthy as we ought to be, or as well educated; a long way from having all the literature and art and music and travel we could enjoy.

The Hungry Two-Thirds of the World

And even if we arrive fairly soon at a point where we feel we have enough of everything (which is not very likely), there are the people in the underdeveloped countries. *They* are not going to run out of wants in a hurry. They have a long, long way to go before they will even be tolerably well fed and housed, to say nothing of health, education or modern conveniences. Making automation serve them may be, probably will be, an even tougher job than making it serve us. But it has even bigger possibilities and presents even bigger opportunities.

The problem of automation and employment in Canada can be solved. But it will not solve itself. Automation can give all of us more leisure without throwing any of us permanently out of work. It can give us a much higher standard of living. But it will not do either unless we act to make sure that it does.

It can make goods cheaper; but only if monopolies don't get in the way.

It can shorten hours; but only if employers don't decide that it's simpler and cheaper for them individually at any rate, to lay people off rather than to spread work.

It can give us much higher wages, but only if management and investors don't obtain more than their share of the increased productivity.

It can benefit us in the long run; but only if we see to it that it benefits us in the series of short runs which make up the long run.

4

WHAT WE MUST DO

Government, management and the trade union movement all have their parts to play.

The first necessity is to make sure that when automation destroys jobs there are other jobs for the displaced workers to go to. In other words, we must establish and maintain full employment. That is primarily the task of government, through monetary policy, tax policy, tariff policy, deficit and surplus financing, public investment policy. That is not by any means all that government has to do, but unless it does this, nothing else it can do will be effective. For example, training new workers, or retraining old workers, for new jobs won't help much unless there are enough new jobs to be trained for. A highly qualified electronic technician unemployed is just as unemployed as the most completely unskilled labourer.

The government can and should provide the general conditions for full employment. It can also help to keep up consumer purchasing power by maintaining and increasing social security payments: unemployment insurance, old age pensions, family allowances and so forth. But a considerable part of the task of keeping up consumer purchasing power devolves upon the trade union movement. With automation, it will increasingly be union policy to keep pressing for the highest wages that industry can pay.

We must have enough jobs to go round. But that, by itself, is not enough. It is full employment in theory. It is not necessarily full employment in practice. The jobs may be the wrong kind, or in the wrong places, for the workers who are available. There might be enough jobs and still a lot of unemployed.

We have been asking what automation will do to jobs, and have been considering what it will do to the *quantity,* the *number,* of jobs. But we have also to consider what it will do to the *quality,* the *kind,* of jobs, and to their *location.*

Everyone agrees that automation will destroy some jobs, change others, and create new ones. Everyone also agrees that automated industries will need a smaller and smaller proportion of unskilled and semi-skilled workers and a larger and larger proportion of professional and skilled workers. There will be a general upgrading of the labour force. And to a large degree the professional and skilled workers will be new kinds.

Dr. Otto Pragan, Director of Research and Chemical Education for the International Chemical Workers Union, for example, told the Congressional subcommittee that in the last eight years, while production in the organic and inorganic chemical industries increased 53%, the number of production workers rose only 1.3%, but the number of non-production workers rose more than 50%. In 1947, the ratio of production to non-production workers was three to one. By 1954, it had fallen to two to one. Non-production workers are "professional people, like engineers and chemists, and supervisory personnel, plant managers, foremen, and clerical people". Maintenance workers are classified as production workers, and Dr. Pragan estimated that some chemical plants employed as many as one maintenance employee to every two other production workers.[106]

In the communication equipment and related products industries (U.S.) in the first seven months of 1955, the ratio of production to non-production workers was about 2.5 to one.[107]

Designing automated plants, designing and installing the machines, redesigning products, will need a much larger number of electronics and "system" engineers than we have now. We shall have to produce many new engineers of these new kinds, and retrain many older engineers who, perforce, can have had no experience in this field.

A recurrent feature of the evidence before the Congressional subcommittee was the emphasis on the immense need for engineers; and Dr. Patrick has told this Royal Commission that, according to an authoritative magazine, "the requirements for electronic engineers alone in the United States will increase 227% by 1960."[108] There is nothing to suggest that our need will be less, if we want to keep pace with American industry.

"Programming" the computers will need a great many trained people. Mr. Burgess, of the U.S. Bureau of the Census, told the Congressional subcommittee: "Very detailed and explicit instructions must be provided to the computer before it will proceed through any operation. A computer, for example, doesn't even know when to stop except when explicit directions coverings these elementary functions are included in the instructions prepared for it. This applies not only to a complete task but to hundreds and sometimes thousands of subparts within subparts which, when executed in the

proper sequence by the computer, result in the solution of a complex problem. The preparation of these lists of instructions known as programmes involves specially trained personnel with varying degrees of skill. . . . The principal programmers . . . must be thoroughly familiar with the problem to which the computer is to be applied as well as the logical system and characteristics of the computer to be used. . . . Less skilled personnel . . . need know only the logical system of the computer and be capable of filling in the detailed instructions in small pieces of a total programme. The less skilled personnel need not necessarily understand how the pieces they prepare fit into the large mosaic which makes the whole."[109]

Before General Electric installed its big computer at Evendale, Ohio, in 1952, it employed about 30 girls in that department for manual calculation. In 1955, it employed only 20 in that capacity. But it employed 40 as programmers, all more highly trained (and more highly paid) than the 1952 variety. Eight of them had professional standing. It also had about 50 male employees analyzing and programming problems, and operating the night shifts. And "As we learn how to use computers, we will give them more work to do. This will require more people to prepare the problems for the computers . . . and more people to interpret and use the results produced."[110]

Nor is this the whole story. Before the computers can be introduced at all, trained people who know a great deal about both mathematics and the business concerned have to chart the flow of data through the existing, non-automated system, work out a revised system which the computer can handle, and plot this system in the symbolic form the machine can "understand", so that the instructions can be fed in in the form of punched cards or tape or magnetic tape. Management expects to need a lot of people like this.[111]

Operating the control systems and computers will also need a lot of trained people. Mr. Burgess told the Congressional subcommittee: "Much has been printed in the popular press about how automatic and self-contained these devices (computers) are. You may have heard about how internal checking facilities, or checks for accuracy which are included in the instruction programme, can insure against incorrect results. The very existence of these facilities established the fact that sometimes checks are not satisfied. When this occurs there must be human intervention by an operator. The art today has not reached the point at which the equipment can be left unattended for periods of even an hour unless the user is willing to take a great risk that during a major part of that hour the computer will just be stopped waiting for an operator to press the right button or take some other action to start it again. Because of the high cost of lost time and the need for fairly frequent operator intervention to identify and correct difficulties or supply additional input material, it is important that operators of large-scale computers be more highly skilled and trained than is necessary for more traditional office equipment."[112]

Maintenance of automated factories and offices will also create a demand for many trained people, and some new kinds of maintenance staff also: the instrument man, the combined mechanic-electrician, the electronic technician. And these people will be far more important than maintenance men in the ordinary factory, because stoppages in an automated plant are so much more costly. The economic advantage of automation depends very largely on continuous operation.

Training and Re-training

In short, there will be many new job opportunities. There will also be an ample supply of people to take advantage of them. There will be the normal supply of young people. There will be the displaced unskilled and semi-skilled workers. There will be skilled workers whose particular skills have been taken over by the machines.

But to bring the opportunities and the workers together, and so provide jobs, will require training and re-training. Government and management will have to do most of this, though union co-operation will, of course, be essential.

The schools will have to give the young people their basic training: not so much training in particular jobs (which, with the rapid development of technology, may well be obsolete before the training is completed) as training in the necessary mathematics and other basic subjects which will enable them to understand the new jobs and acquire the specific new skills in training on the job.

It is a matter not only of the schools but also of the universities. The United States is not producing enough engineers or technicians for its present needs, let alone its much greater needs of the near future. Over and over again, witnesses before the Congressional subcommittee pointed out that in 1956 the United States will graduate only 27,000 engineers to the Soviet Union's 45,000, and only 50,000 technicians to the Soviet Union's 1,600,000.[113] Canada's engineer supply situation Dr. Patrick describes as "desperate", and made more so by our loss to the United States of some of the "too few" engineers she is training. He points out that "Engineering training requires a minimum of four years at university and an additional four years in industry before a man becomes competent in his field. At least eight years will pass before significant improvements in the Canadian situation can be expected. . . . In the United States 33% of the youth in the appropriate age groups is registered at a university. In Canada only 7%. In ten years the United States expects that 45% of the appropriate age group will be registered in universities, in Canada only 10%. The relative lack of research and development opportunities in Canada plus the wholly inadequate undergraduate and graduate school training in Canada's universities constitute a

very real threat to the logical and very highly desirable growth of the electronics industry in Canada."[114]

Dr. Astin, of the National Bureau of Standards (U.S.), told the Congressional subcommittee that "the critical area" was the high schools, "primarily high-school teachers. I don't think we pay our high-school teachers enough, and I don't think we can get teachers who will inspire people to take up science and engineering as a career unless these people themselves are sold on it, and with the great shortage we now have of scientists and engineers, it is difficult to get anyone with any competence to do the teaching in the high schools."[115] The Ontario College of Education, the only institution in our most highly industrialized province which is training high-school teachers, is about to graduate 310 teachers. Only about a third of them will be "Type A" (what used to be called first class, till some of the professional "educators" took a notion that such a term was not "democratic"), and of these only 13 will be qualified to teach science or mathematics, as against 28 to teach physical education.[116] And it is putting it mildly to say that there is widespread uneasiness both in the United States and Canada about the thinness of what the high schools do teach in mathematics and science. Canadian universities complain constantly that the students sent to them are grossly deficient in knowledge which they ought to have; and a recent article in an American magazine says flatly that Russian high school graduates in physics know more than the second year M.I.T. student "majoring" in that subject.[117] This is an alarming state of affairs, and merits the closest attention of both Dominion and Provincial governments.

Government, or government and management together, will have to take the responsibility for re-training displaced workers. To some extent, American industry is doing this now. Mr. Donovan, of Ford, told the Congressional subcommittee that "the average length of service of our operators on the cylinder-block line and in the new Berwin engine plant is 25 years. Those people have been trained in the old processes and then retrained to the new processes, and we found that we were able to accomplish it with very little difficulty. . . . In addition to on-the-job training, as we move employees from the old system and put them on the new system, special courses of instruction were developed. For example, in the engine-manufacturing operations, a machine-tool familiarization course was developed that involved presentations by 15 different machine-tool-building companies to approximately 500 job setters and job foremen. Each one of these presentations lasted approximately 1½ hours and was intended to familiarize these key employees with the new equipment. Training courses were also developed for maintenance personnel, including courses of hydraulics, quality, lubrication, electrical and electronics, and an overall special programme on automation." He added, however, significantly: "Our training is developed primarily for the maintenance people and the foremen."[118] Dr. Pragan told the same subcommittee that "in some of our plants we have set up certain programmes, one-year,

two-year, three-year programmes, where people whose jobs are abolished are being retrained."[119] Dr. Brunetti described how General Mills, in conjunction with the Minneapolis Vocational High School, set up courses in soldering, blueprint reading, fitting gears to shafts and electromechanical inspection techniques. "General Mills expert personnel served as instructors in the school. The company provides material and specialized equipment and works with the school in recommending and designing courses. Now in this case, trainees attend on their own time, but the company provides the tuition."[120]

Is re-training going to be beyond the displaced worker's, particularly the unskilled worker's, capacity? Several witnesses before the Congressional subcommittee emphatically thought not. Mr. Burgess said the less skilled electronic technicians required for computers "can be recruited with training in other aspects of electronics and provided specialized training on the computer in a comparatively short period of time, usually measured in months. . . . Practically all our staff working in these various types of positions (programmers, operators and maintenance personnel) represent persons with appropriate background and aptitudes who were working in the Bureau of the Census prior to our acquisition of the computer, and who have been trained and have developed the necessary experience while on the job in the Census. . . . We have had to hire from the outside only one or two."[121] Mr. McPherson, of the same Bureau, added: "The training of the people that have done much of this programming has been successful, and very short—a matter of only a few months."[122] Dr. Brunetti said: "Now I would like to answer this question, does a labourer have to be an MIT graduate to work in the factories of the future? . . . At one time we hired several hundred unskilled people over a period of two to three years, and they were sent by the company to attend school until their skill on a machine was sufficient for them to return as a qualified precision operator. In most cases these people were trained to work on drill presses, lathes, milling machines, gear cutters, grinders and other shop machines, in a period of two to three months. . . . I have listed 23 new types of jobs that have been created by automation, and this list is only a small list. . . . Only four out of the 23 are college graduate type. You do not need a college degree to run an automation machine."[123] Dr. Vannevar Bush said: "There are very few men indeed who are not capable of learning to do more complicated and useful skills, if they are willing to learn, if they are encouraged to, and if the full cost of learning is shared by the employers and the unions."[124] Dr. Brunetti emphasized the necessity of more public or vocational trade schools.[125]

And while people are being trained and re-trained, they have to eat. So somebody will have to provide them with income. Government will have to provide more schools and more teachers of the necessary kind. Government and management together will have to provide more scholarships and bursaries, and loans at low interest or no interest for students capable of

handling the new jobs. Management ought to provide maintenance for displaced workers whom it is re-training. That is a part of the social cost of automation which ought to be borne by those who introduce the new processes, for their own profit.

Re-training some of the oldest workers may turn out to be impossible, or impossibly expensive. The number will probably not be large. But whether they are many or few, these workers must be provided for. Their unexpectedly early obsolescence is another of the social costs of automation, and at least part of this cost also ought to be borne by management in the form of adequate severance pay. This should be supplemented by higher old age security payments, available at earlier ages, or by suitable changes in pension plans, or both.

Location of Industry

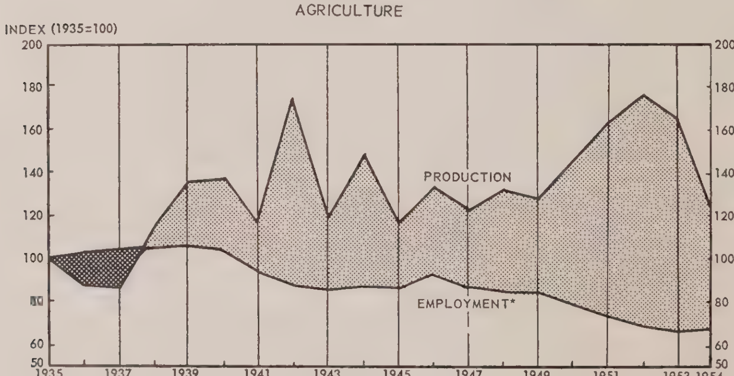
Automation may drastically affect not only *how many* jobs there are, and *what kinds,* but also *where they are.* It may often be cheaper to build a completely new automated plant than to automate an old one; and if you're building a new plant anyway, there may be excellent reasons, from management's point of view, for building it in another place, perhaps a long way off.

The Congressional subcommittee asked Mr. Davis, of Ford: "Do you allow an old plant to sort of wither on the vine and abandon it and go out and start fresh building a new automated plant?" and Mr. Davis replied: "That is what we would like to do. We are not always able to do that because of the expenditures."[126]

CHART 1

PRODUCTION AND EMPLOYMENT — THE WIDENING GAP

AGRICULTURE



* Employment includes farm operators, paid workers and unpaid family workers.

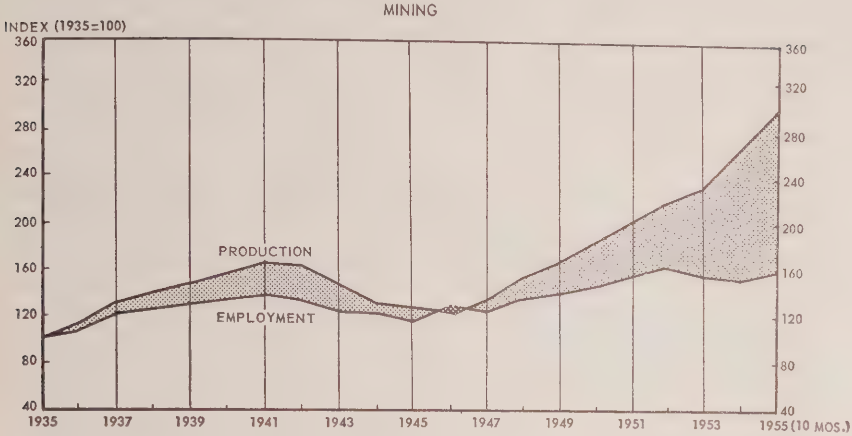
Figures of employment for the years 1935-45 are for June 1, for the years 1946-54, averages of monthly surveys. "Production" means volume of production

Source: Index of Farm Production, 1954, Canadian Labour Force Estimates, 1931-1950, The Labour Force, Ref. Paper No. 58, all D.B.S.

CHART 2

PRODUCTION AND EMPLOYMENT — THE WIDENING GAP

MINING



Source: D.B.S. Canadian Statistical Review. "Production" means volume of production.

It may be easier and cheaper to start from scratch with new workers, instead of having to re-train old ones. Labour in an over-populated, industrially under-developed region will be cheaper, at least at first, and some managements may jump at the chance of getting away from unions. In the absence of social control (by Government or by unions), this sort of thing could leave thousands of workers stranded and a charge on public funds, and create a series of ghost towns, with enormous waste of social capital twice over: homes, schools, hospitals, streets, water supply and sanitary installations, abandoned in one place and needlessly built in another.

Both unions and government can do something to prevent this from happening.

What Unions Can Do: GAW, and Company-Wide Seniority

One thing unions can do is to press for the guaranteed annual wage. If putting the new plant in a new place means paying out substantial sums for mass layoffs, management will think twice, especially as the gains from building the plant elsewhere may be a bit problematical, while the cost of the layoffs, under the GAW, will be certain and immediate.

The guaranteed annual wage has, of course, additional advantages in this context. It will make management careful not only about the *placing* of its new automated plant, but also the *timing*. If management has to pay for mass layoffs, it will try to introduce its new equipment at times when employment is booming and new jobs will be readily available. In the absence of the GAW, it might suit its own convenience and profit, leaving the displaced workers as a responsibility of government.

A further means of controlling the location of new, automated plants, is broader seniority provisions. Plant-wide seniority will no longer be enough. Company-wide seniority, with the company bearing the cost of moving workers and their dependents, is needed to prevent multiplant employers from behaving irresponsibly.

What Government Can Do

But unions, by themselves, cannot handle the whole problem of location of automated industry. For one thing, they may not have enough of the workers organized. For another, getting employers to accept the guaranteed annual wage and company-wide seniority takes time, and may take much too long. Governments may have to step in to enforce social responsibility, to see that what Professor Pigou calls marginal private net profit does not take precedence over marginal social net profit.

They can do this in three ways: (1) they can control the location of industry directly; (2) they can control it indirectly, by offering inducements to stay in particular areas; (3) where the industry must move, or, in the public interest (not just the employer's interest) should move, they can subsidize the movement of workers.

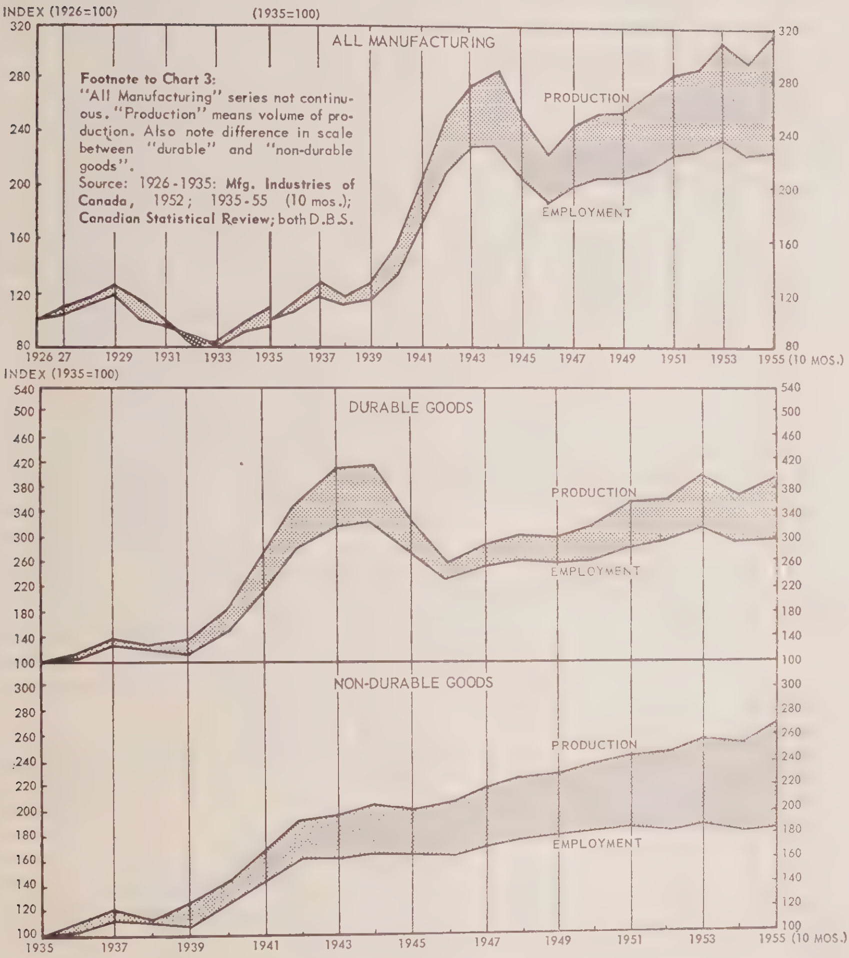
Direct control over the location of industry is a provincial responsibility, because the provincial legislatures have exclusive jurisdiction over "property and civil rights in the province". The legislature could confer on a public board or commission the power to prohibit the transfer of industrial operations of a certain size from one place to another within the province if a complainant (for example, a union or a municipality) could prove that such transfer was not in the public interest. This, however, would be cumbersome and vexatious, to say the least; and it would not touch the problem of transfer to a point outside the province, which might be the most serious problem of all.

Second, either the Dominion or the provincial government could offer tax concessions to firms which would stay in areas officially designated as "special areas", from which the migration of industry was, in general, considered by the government in question to be undesirable. This would be an adaptation of the policy followed in the United Kingdom in dealing with depressed areas like South Wales. Also, the governments could channel their own purchases to firms which co-operated; and, with government purchases on the scale which prevails now and is likely to prevail for as long as anyone can foresee, this could be a powerful instrument of persuasion.

Third, where firms insisted on moving their operations, and could not be prevented, the governments could assist planned migration of workers and their families.

CHART 3

PRODUCTION AND EMPLOYMENT — THE WIDENING GAP



Management will probably object that the first method is an intolerable interference with its rights, the second expensive and open to abuse, and the third a burden on the taxpayer, notably the industrial taxpayer. The answer is that if management will accept its social responsibilities, governments will not have to take any of these measures. But if management is irresponsible, and widespread dislocation and suffering results, then the public, which must foot the bill, will insist on government action.

Automation and Union Policies

Some things that unions can, and no doubt will do about automation have already been noted: press for higher wages in general, for the shorter work-week, for longer vacations and more statutory holidays, for better pension plans, for higher unemployment insurance benefits and old age security and family allowance payments, for the guaranteed annual wage, for company-wide seniority, for more and better professional and technical education, for training and re-training, for severance pay, for the right government monetary, tax, tariff and investment policies. But there are other things also that unions must do.

Specifically, they must press for higher pay for automated and semi-automated jobs. Management may well try to pay a new job, which requires more knowledge and more training, and involves more responsibility, at a rate established for an old job which was really altogether different. Unions will have to insist on new classifications for new jobs, or management will get more than its share of the fruits of technological progress, and the mass purchasing power on which the whole industrial system depends will suffer.

This point, it should be noted, is quite distinct from either general wage increases or general "improvement factor" clauses.

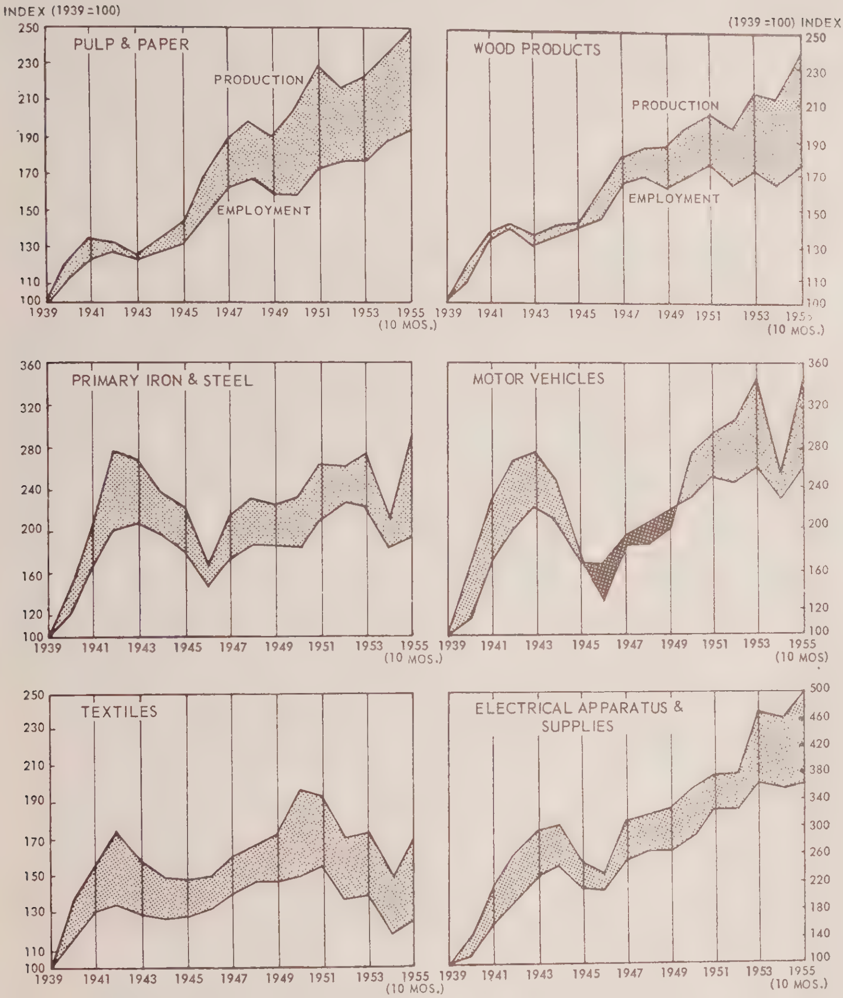
Unions must also press for broader seniority provisions. Narrow seniority may mean that workers whose particular skill has been rendered useless are left high and dry. "Ability to *learn* the job" may have to replace "ability to *do* the job".

Unions in industries which are undergoing automation, or likely to undergo it, may find it necessary to insist on short-term contracts, or on much more flexible provisions in long-term contracts, to enable them to deal promptly with new situations.

Where there are two or more unions in an automated industry, they may have to work out new forms of co-operation, or even merge, in order to bargain effectively with giant employers. Big companies are no longer confining their operations to a single industry or even a group of related industries. They are branching out into all sorts of new fields. Unions cannot afford to be less up-to-date, or less flexible, than the managements they confront.

CHART 4

PRODUCTION AND EMPLOYMENT — THE WIDENING GAP



Footnote to Chart 4:
"Production" means volume of production.

Source: D.B.S. Canadian Statistical Review.

5

AUTOMATION AND SMALL BUSINESS

MANY PEOPLE think that automation will sound the knell of small business, chiefly because the automatic equipment is so costly. But as we have seen, this costliness can be exaggerated. Diebold says: "In certain fields enormous concentration of engineering ability and large development expenditures are necessary. It has been apparent for some years that, for the most part, the days of the lone inventor are over. This is true, for example, of the major strides in the chemical industry. But a surprisingly large number of new products is marketed each year by small concerns. This is especially true in the field of electronics—where, encouragingly enough, considerable research and development are required. In fact, the prevailing philosophy in the new product departments of some of the largest concerns is that development attention should be given only to those products not easily produced by small competitors—for licensing of patents has been deemed by many large concerns the wisest way to minimize the danger of anti-trust prosecution.

"As flexible, standardized, automatic materials-handling equipment is developed, companies will manufacture such equipment for sale, or lease, in the same way that controls themselves are manufactured by companies such as Minneapolis-Honeywell. Each firm will not have to do its own basic research and development on the application of the new technology.

"The development of control mechanisms is considerably ahead of the development of automatic equipment. Using the former as a guide to the latter, we see that very few individual firms have to design their own instruments or control devices. The number of companies making instruments has increased from 684 in 1935 to 1,363 in 1950. As the technology is applied to materials-handling equipment and to standardized fabricating machinery, these products too will be manufactured on a standard basis by concerns wishing to sell such equipment. Research and development requirements,

therefore, are not so high for the firms using automatic equipment as they may appear at first.

"There is, of course, demand for effective analysis of a firm's present operating procedures and of the changes necessary to make them suitable for installation of automatic equipment. Such work usually requires engineers. Then, too, the machinery itself must often be adapted to the requirements of the firm, although much of this can be done by the companies manufacturing the automatic equipment. Reliable consulting firms can do much of the analysis of present operations and the adjustment of these operations to automatic control.

"The basic research on controls, and to some extent on the industrial use of these controls, is being paid for primarily by military and other government funds. If expenditures of this sort should suddenly stop—a very unlikely possibility for at least the next several years—such research would have to be carried on by some other means, but it is clear that very few industrial concerns could afford the immense expenditures for basic industrial research of this type. Establishments such as the Bell Telephone Laboratories have provided some of the most important research, but there are few enterprises of this type in the country. A growing number of industrial research institutions are, however, supported by various companies that provide funds for specific research projects. It is upon such facilities and upon university laboratories that reliance must be placed in the future if effective industrial use is to be made of the new technology.

"Industrial Concentration

"Even though much of the research in connection with the development of automatic equipment is carried on by concerns who intend to manufacture that equipment and even though common laboratory facilities exist for the use of several industrial firms, it is necessary to ask: Will the capital requirements of automation be so great that the small manufacturer will not be able to afford an automatic plant? And if the small manufacturer cannot afford to use the new technology, will he be squeezed out of the economic picture by large competitors who can? In short, will automation mean only that the rich get richer?

"Automation itself will not produce any startling increases in the degree of industrial concentration. To be sure, the capital costs of an automatic plant will be high—just as are the costs of all plant and equipment today. Certain industries, as is the case today, will be barred to all but those having immense capital resources. But opposed to this there is much evidence that decentralization in ownership, as well as in physical plant, may play an increasingly important role in shaping our economy during the next generations and that industrial concentration will no longer be the bogey it once

seemed. This will be true partly because we are beginning to realize that small industry *can* survive alongside industrial giants and partly because there are positive forces at work in the economy to further the role of small business.

"The growing use of electricity as a prime power source and the introduction of light new materials are two important factors working toward decentralization rather than centralization of industry. No longer is it necessary to have a very large operation in order to justify the use of an efficient power source. Certain fabricating operations can be carried on in very small plants by the use of electric power as the prime motive force. The fact that automation requires less direct labour means that automatic plants need not be placed in concentrated labour markets but may be situated in far less densely concentrated areas. As flexible automatic equipment is developed and appears on the market, it will be possible for smaller concerns to operate on an automatic basis and to compete very effectively in price and cost with larger concerns in a great many fields. New materials, such as the plastics and light metals, also allow smaller concerns to grow and operate efficiently in specific areas of the economy. The increase in the number of small firms since the war, especially firms manufacturing new products, is an interesting commentary on capital requirements of manufacturing concerns in a new and rapidly expanding era of technology."[127]

Dr. Vannevar Bush told the Congressional subcommittee: "Another thing that automation does which is to me exceedingly interesting is to decrease the flexibility of a given industrial production operation, and thus to increase the costs of a changeover. Hence the more extreme forms of automation are applicable only when a given product or a given design is going to be made in large quantities and for a very considerable period. The one would expect extremes of automation to occur in large industrial units and this is indeed the case. But the fact that flexibility is decreased is to me a very interesting matter. For the mere presence of automation is producing in this country opportunity for small industrial units to prosper in a way that I feel is very healthy from the standpoint of our whole industrial situation.

"During the war I had the privilege of working with a very large number of young scientists and engineers. Many of these men were thrown out of their grooves by the war and at the end of the war did not re-enter the industrial system in the old manner. A surprising number started new small businesses all over the country. These were very often centered about the making of a new instrument or device which had a special use in a relatively limited market but on which a reasonable profit could be made.

"Without doubt this trend toward the introduction of new industrial units has been furthered by military purchases and military development. But it has also been helped greatly by the trend toward automation, for many

of these small companies are making apparatus for that purpose, mechanical or electronic.

"They can prosper in fields where there are large, well-managed companies operating primarily for the reason that they are exceedingly flexible, they can get close to their customers and meet their needs intelligently, and they can change rapidly with the times and the trends.

"The point that I wish to make is that if large manufacturing companies turn to automation in extreme form, they thereby not only make a market for small companies of this sort but they also increase their own rigidity and render it more possible for the small industrial unit to prosper by reason of its inherent flexibility. This seems to me an important point, for I have long felt that our primary reliance against undue concentration of industry in this country lies in the continued advent of new small, aggressive industrial units. Thus automation may have some effects that tend to increase the size and relative proportion of production of large units, but it also has imported effects in just the other direction."[128]

Diebold concludes his discussion of this problem by noting how the survival and growth of small business can be aided both by the efforts of business itself and by public policy:

"Perhaps the most hopeful example of small firms operating aggressively and efficiently in the area of new advanced technology is the group of companies sponsored by the American Research and Development Corporation. This corporation, headed by General Georges F. Doriot, was founded after World War II by Senator Ralph Flanders and a group of farsighted businessmen for the purpose of channeling capital into new ventures—ventures principally based upon technological innovations. The backing by American Research of a group of 16 corporations, all small, is one of the most hopeful signs in the American economy today. Not only is American Research showing that small companies can still play an active, aggressive role in a highly technical area of the economy and live side by side with well-managed, capable, large firms, but it also provides a thoroughly workable example of the way in which the equity capital shortage of recent years can be overcome."[129] (In this country, the Industrial Development Bank might play a similar part.)

Diebold's specific comments on public policy naturally have to do with the United States. But the general point applies here as much as there. If we think it socially desirable to preserve small business, then we shall almost certainly find it necessary to adopt public policies designed to that end. To some extent, we have already done so, notably in our anti-combines legislation. But this is almost certainly not enough. What else we should do is one of the many things connected with automation which demand careful, and prompt, study.

6

FINDING THE ANSWERS

EVEN IN the United States, where governments, corporations, universities and unions are alike immeasurably richer than here, where immeasurably more has been written on the subject than here, where the Department of Labor has already done at least two case studies, and where a Congressional subcommittee has conducted long and useful hearings, there is general agreement that further research on a large scale is essential. Mr. Diebold told the Congressional subcommittee: "To my knowledge, no economic study has yet been undertaken to discover precisely how automation affects the structure of industry, the labour force, and human relationships. The significance of automation is widely recognized . . . yet of the precise nature of that significance little has been said, for the simple reason that little is known, in a comprehensive, quantitative sense.

"The problem . . . is that we do not have the facts. . . . It seems to me highly desirable that we get these facts in the most expeditious way possible: through a thorough analysis of automation, based on a complete, factual industry-wide investigation. . . . National policy concerning education and training programmes, retirement benefits, and unemployment compensation must be based upon such a factual and intimate understanding."

Mr. Diebold goes on to suggest a series of questions which need to be answered: "How does automation affect the stability of employment? How does automation affect the relative income shares of capital and labour? How are wages in automated industries altered relative to wages in non-automated industries? What is the process by which wage increases (or other benefits) in automated industries spread to non-automated industries? How does this affect inter-industry competitive relationships (i.e., are there examples of companies forced to close all or part of their production facility because of inability to meet higher wage rates in an automated industry, or are these increases passed on in higher prices?)".

He proceeds: "It seems to me that there is, at this point, only one useful way of collecting, organizing and analyzing the information necessary to such a study as that which I have proposed: a detailed case-by-case approach to a number of specific industries which are regarded as typical of the several kinds of automation practiced today. The schedule of industry and labour spokesmen to be witnesses to these hearings indicates, it seems to me, that the members of the committee also consider such an approach valuable—although for the purpose of a factual study, of course, much wider sampling would be required.

"There are a number of organizations—foundations, government agencies, universities, private consulting firms—qualified to conduct such a study at the present time. Since the subject seems to fall naturally into certain divisions of major significance, the study itself might well be similarly divided among a number of specially qualified agencies. I should certainly think that some sort of government sanction, official or otherwise, would prove an enormous advantage in obtaining the information required.

"A great deal of the necessary information might be elicited through detailed questionnaires and interviews; a certain part of it, however, would require considerable field work by personnel with a background in automation engineering. A likely approach would be to work, at least in the beginning, with the co-operation of automatic equipment manufacturers and engineering consultants who have worked in automation.

"Beyond the general issues I have already raised, I should like to suggest at this point a number of more specific questions which represent the kinds of information which should be gathered for such a study. For purposes of simplification, I have chosen to divide these questions into a number of impact areas: obviously no such division actually exists; whatever affects industry affects labour, and in turn, the entire community. By such arbitrary division I mean only to indicate the nature of the questions involved.

"I. *Automation and Industry*

Answers to the key questions below must be sought by analyzing developments within particular industries.

A. What industries are using the techniques of automation?

B. How are these techniques being applied? What degree of the total production capacity may be described as automated?

C. How rapidly is automation being introduced? When did the industry (company) first begin consciously to automate? What current technological or economic development might affect the rate and/or degree of automation?

D. To what extent (in a given company) does automation permit the manufacture of goods or the performance of services not possible otherwise? To what extent does automation permit production of goods and performance of services now possible but with less labour and/or capital? (See F-3.)

E. What industries not highly automated could be so, if present technological advances were applied? What has prevented the introduction of automation in these industries? Within highly automated industries, what companies have conspicuously not automated? What are the reasons given? How many companies avoid automation because they cannot afford the initial investment? Because they don't want to take risk?

F. How is industry structure being affected?

(1) Is there a tendency toward greater centralization or decentralization?
  (a) Geographically?
  (b) Administratively?

(2) How is company organization affected?

(3) Will expansion or contraction be the more likely results?
  (a) What is the nature of cost savings made possible by automation?
  (b) How are these savings reflected in pricing policies?
  (c) How does the market respond to a lowering in prices?

(4) What happens to competition?
  (a) As a result of high capital requirements?
  (b) As a result of optimising productivity?
  (c) As a result of patents?

(5) What is the prevalence of merger unions in automated industries as compared with non-automated? How has automation affected the current trend toward product (or service) diversification?

(6) What changes in power and natural resource demands has automation caused?

"II. Automation and Labour

Because the effects of automation vary not only from industry to industry, but also from firm to firm, labour implications must be distilled from case studies analyzing specific instances.

A. In individual industries (company by company) how is employment affected?

(1) What change in total employment (of automated segment) of direct labour? Indirect?

(2) What particular job skills have been made obsolete?
(3) What new job skills are required?
(4) What proportion of new job skills can be easily acquired by workers with obsolete skills?

B. How does automation affect the level and structure of wages?

C. How does automation affect job equity?

D. How are industrial-relations policies and hiring policies changed?

E. What are worker attitudes toward automation?

F. How has automation affected collective bargaining?

G. How has automation affected working conditions (Safety? Machine packing? Increased responsibility? Improved work area?).

H. How have union jurisdictions been affected?

I. How has internal union organization changed?

"*III. The Automation Equipment Industry*

It has been estimated that in 1954, $3 billion was expended on automation equipment; and that by 1960 the volume will expand to $10 billion. What are the characteristics of this industry?

A. What is the nature of the firms producing automation equipment? What proportion are new firms? Of old firms, how great a part of the total production effort is involved? Does this represent a major diversification? How rapidly have firms expanded in this field? What is the incidence and nature of mergers?

B. What portion of total output is absorbed by military and/or defense needs? What is the role of the government in purchasing, research, and product development?

C. What is the effect of patents?

"*IV. Education and Automation*

Automation greatly increases the need for personnel trained in the design, construction, supervision, and maintenance of automatic equipment. It increases our already urgent need for more engineers, and imposes a special demand for a new kind of engineer—the system engineer. From top management to the semiskilled production-line worker, automation requires entirely new kinds of training.

A. What are the specific retraining and educational requirements of automation?

B. What kinds of training programmes have been undertaken? By firms? By public schools? Private institutions? Unions? Equipment manufacturers?

C. Upon whom should the responsibility and cost of retraining fall? The worker? Company? Equipment manufacturer? State or Federal Government?

D. How has the present supply and quality of engineers and technical personnel affected the degree and rate of automation? Has a shortage of trained personnel discouraged any firms from introducing automation? How has this supply affected the development and production of automation equipment?

E. Does automation increase or decrease the range of jobs for which women are qualified?

F. What specific problems does automation raise for older workers? Is the nature of retraining necessarily too difficult for older workers? Have companies shown an unwillingness to retrain older workers because of the comparatively reduced return?

"V. *Automation and the Community*

Beyond the challenge to the community implied in all the previous questions, automation suggests another special question of considerable significance. Labour leaders have consistently cited the shorter work week as their next objective, after the establishment of the guaranteed-wage principle. J. Frederick Dewhurst, director of the Twentieth Cenutry Fund, has estimated that by 1975 Americans will be working a 32-hour, 4-day week.

A. How will this increased leisure affect consumption patterns? How will this, in turn, affect the growth of service industries?

B. How will this affect the requirements of our transportation, educational, and recreational facilities?

C. Does it imply a need for basic changes in the nature of our primary and secondary school training? (i.e., Is it true, as some psychologists observe, that the majority of people in this country are not able to make effective use of increased leisure opportunities?)"[130]

The CIO proposed that the subcommittee should itself make a continuing study of the whole subject, and suggested that its work should include:

"1. *Case Studies*

Such case studies should include the number of layoffs in the plant, by department, to reflect layoffs due directly to the installation of automation equipment or indirectly, through bumping, for example; types of workers laid off by sex, age, skill, job classification, and seniority; types of workers

who have obtained new jobs in the plant, by sex, age, skill, job classification and seniority; changes in job contents, job classifications, skills and wage rates—including dilution of skills and wage cuts, as well as upgrading; provisions, if any, for re-training the work force; labour-management relations aspects—such as possible joint consultation in preparation for the installation of new equipment and continuing consultation to iron out problems; changes in rates of output; extent to which the new equipment is being used to fullest efficiency at the time of the study and what changes in employment, job contents, wage structures, etc., may be expected in the future as use of the equipment improves in efficiency; estimates of the cost of new equipment, rates of output, required size of work force, and wage rates, by comparison with previous type of equipment; experience of workers who obtain new jobs on new equipment, with special emphasis on the experience of older workers; experience of laid-off workers in finding new jobs, what types of jobs in relation to skill and wages, in same or different industries, in same or different communities.

"Attempts should be made to engage in on-the-spot studies before, during and after the installation of new equipment. An original case study should be followed by further study or studies of the same plant, after a time interval, to obtain an adequate picture of the adjustment problems.

"2. *Industry Analyses*

Analyses of specific industries which are not possible from regularly published available data—such as electronics industry or the radio and television industry alone—to include the extent to which automation equipment is now operating, as well as plans for the installation of such equipment in the next several years; comparisons of employment by type (production, maintenance, supervisory, clerical) with output, over periods of time; changes in composition of work force; changes in man-hour output and in output per unit of fixed capital; changes in prices of goods produced by the industry; changing relationships among firms in the industry—such as the effect of new equipment on the competitive advantage of individual firms; does automation in one firm or group of firms curtail output and employment in other firms; competitive position within the industry of smaller companies; changing geographic location of plants in the industry; impact on communities—to what extent are old plants in the industry closed down and new plants built in new areas and the effects on old and new communities in terms of employment and unemployment, and general living conditions.

"3. *Broad Analyses of Employment*

Analyses of shifts in employment by broad industry and regional categories—which industry groups and categories are growing, which are stagnating, and which are declining; shifts in types of employment, such as hourly

paid workers, skilled and unskilled production workers, maintenance, supervisory, and clerical employees.

"4. *Collective-Bargaining Provisions in Relation to Technological Change*

Studies of provisions in collective bargaining agreements in relation to the installation of new equipment—such as joint consultation provisions, company-financed retraining programmes, provisions for unemployed workers, such as guaranteed wage plans, provisions for severance pay in the case of laid-off workers, and other similar provisions, with sample clauses and estimates of the extent to which such provisions exist.

"5. *Business Investment*

Studies of present and planned fixed capital investment by industry groups, in an attempt to obtain, if possible, estimates of expenditures for expanding output as distinct from replacement; expenditures for automation equipment, comparative costs of new equipment and old equipment, and comparative output of old equipment with anticipated output from new equipment; also, studies of technological changes and new machines, being introduced or planned for introduction by industry group, for the next three to five years. Such studies should be based on studies of the capital equipment producing industries, as well as on the industries for whom the equipment is produced.

"6. *Education Facilities*

Facilities for retraining present work force in new skills; facilities for training new workers in required skills; facilities for education of professional engineers, technicians, and skilled workers, number of such facilities, instructors, and students; quality of facilities and instruction."[131]

7

THE CANADIAN SCENE

IN CANADA, some of the investigation might not take as long as in the United States because automation has probably not gone as far as there. But other parts of the work might, for the same reason, take longer; and a Canadian inquiry would have to consider problems which do not arise in the United States: problems raised by the fact that automation in Canada will have to take place side by side with automation in the much larger and richer United States. Some of such problems are: whether American automated industries with branch plants in Canada will think it worth while to automate in Canada, or whether they will close down here and supply the demand from their American plants; whether American automated industries will let us use their patents; whether we shall have to depend largely on the United States for our supply of automation equipment; whether higher pay in the United States will lure away all our brighter young scientists, engineers and technicians, and leave us simply unable to automate to any considerable degree because we shall lack the people with the know-how.

All these are reasons why we could not just take over the results of an American investigation of this subject, invaluable as they might be. And there are other reasons. Federal and state jurisdiction in the United States are not the same as Dominion and provincial jurisdiction here. For one thing, we have a single national system of unemployment insurance, where they have a wide variety of state systems with federal aid. For another, labour relations here fall much more under provincial jurisdiction than labour relations in the United States under state. For a third, our anti-combines policy is different from the American, partly because of the wider jurisdiction of our provinces in economic matters. Generally speaking, the central government in the United States has more effective control of the national economy than our central government here; so that measures which there could be effective without action by the states might require imperative action here by the provinces.

Much more knowledge is needed. "Public policy", says Dr. Edwin Nourse, "should be framed in the light of the fullest possible understanding of the integrated character of the price-income structure and the behaviour of our economy, with an eye to promoting 'maximum production, employment and purchasing power' for the whole people, not to serve the interests of any special group.

"This sort of scientific and engineering rationalization of our national affairs calls for a simply stupendous amount of grassroots data as to what is actually happening at an infinite number of spots in the economic process. That mass of data is too voluminous to be seen, classified, and evaluated by statisticians, economists, and statesmen and processed into generalizations which can guide legislators and executives, public and private, in discharging their necessary function of programming the economic process and of presetting the control mechanisms that determine the value flows throughout the economy, and thus lead to full and efficient use of our resources or to delays, wastes, or breakdowns in the mechanism.

"Fortunately, the development of the electronic computer or mechanical brain makes it possible to process these vast bodies of relevant data economically and accurately, thus giving an adequate and reliable base—I want to reiterate, to give a more adequate and reliable base—on which human judgment can be exercised as to the course which economic policy and action should follow."[132]

But we must all resist any temptation to postpone action "till all the facts are in". They never will be. They never can be, not even with all the giant computers working full time. Too many different things are constantly happening too fast and all together. We must investigate and study and plan; but we must also act, and act promptly, on the basis of the facts we have and the new facts as they come in.

FOOTNOTES

1. Diebold, in *The Challenge of Automation,* p. 14; Public Affairs Press, Washington, 1955 (papers delivered at the C.I.O. National Conference on Automation, April 1955). Mr. Robert C. Tait, president, Stromberg-Carlson Co., at pp. 198-200 of *Automation and Technological Change* (hearings before the United States Congressional Subcommittee on Economic Stabilization, 1955; hereinafter referred to as *Automation and Technological Change),* described five "major areas" of automation: "No. 1, an old one, continuous-flow process: . . . principally in the oil and chemical industries. No. 2, the multiple-tool application: . . . Detroit automation . . . No. 3, numerical control: . . . This is the method whereby a machine tool is hooked up to an electronic computer or programmer and instructions are fed to the machine by means of punch-cards or magnetic tape. . . . No. 4, the automatic assembly of electronic components. . . . No. 5, data processing: This field is comprised (sic) principally of computers."

2. "The feedback principle itself is nothing new but the modern application is new in that the feedback information is handled by electronic means." (Tait, *Automation and Technological Change,* p. 197).

3. Cf. Edwin G. Nourse, *ibid.*, p. 619: "Electronic mechanisms make it possible to conduct more elaborate, more economical, and more precise continuous-production operations because the outcome of the process controls the process itself, starting, altering or stopping it so as to make it produce a desired result. This should dispose of the cliché that automation is nothing new, just more mechanization. It has its roots in mechanization, to be sure, but something new was added when electronic devices made possible the widespread application of the feedback principle."

4. Norman DePoe, in *Maclean's,* October 1, 1955.

5. Weinberg, *op. cit.,* p. 3.

6. *America's Needs and Resources,* J. F. Dewhurst and Associates, New York, The Twentieth Century Fund, 1955, p. 870.

7. Joseph A. Beirne, President, Communications Workers of America, in *Automation and Technological Change,* pp. 345-346.

8. *Trainmen News,* July 4, 1955. For ten other examples see *Automation and Technological Change,* pp. 456-458. For a detailed description of what they do and how they do it, see *ibid.,* pp. 543-558.

9. *Industrial Canada,* January 1956, p. 48.

10. Weinberg, *op. cit.,* p. 5.

11. *America's Needs and Resources,* p. 871.

12. *Industrial Canada,* January 1956, p. 47.

13. *Saturday Review,* January 22, 1955, p. 40.

14. *Ibid.,* p. 40.

15. DePoe, *loc. cit.*

16. Diebold, *Automation,* Van Nostrand, New York, 1952, pp. 94-95.

17. DePoe, *loc. cit.* For detail, see *Automation and Technological Change,* pp. 445-446.

18. R. J. Bibbero, in *Electrical Engineering,* September 1955.

19. Walter Reuther, president, United Automobile Workers, at p. 100 of *Automation and Technological Change,* quoting *Fortune,* October 1955, p. 131.

20. Reuther, *loc. cit.,* quoting the *Wall Street Journal,* June 17, 1955.

21. *Saturday Review,* January 22, 1955, p. 40.

22. Information from the Dominion Statistician.

23. Diebold, *op. cit.,* pp. 94-95.

24. Abraham Weiss, economist for the Teamsters, *What Automation Means to You,* August 1955, p. 4.

25. *Industrial Canada,* January 1956. p. 45.

26. *Ibid.,* pp. 44-45.

27. *New York Times,* August 18, 1955.

28. DePoe, *loc. cit.*

29. *Ibid.*

30. Bibbero, *loc. cit.*

31. Weinberg, *op. cit.,* p. 5.

32. Bibbero, *loc. cit.*

33. *Automation and Technological Change,* pp. 9 and 45.

34. *Ibid.,* p. 9.

35. DePoe, *loc. cit.*

36. I. W. Abel, secretary-treasurer, United Steelworkers of America, in *The Challenge of Automation*, p. 72.

37. *America's Needs and Resources*, p. 871.

38. Weinberg, *op. cit.*, p. 5.

39. Quoted by Reuther, *Automation and Technological Change*, p. 101.

40. *America's Needs and Resources*, p. 867.

41. *Ibid.*, p. 873.

42. Brief to this Commission, February 24, 1956, p. II-24.

43. *Ibid.*, pp. II-24-25.

44. *America's Needs and Resources*, p. 874.

45. *Automation and Technological Change*, pp. 55 and 61.

46. *Ibid.*, p. 201.

47. *Ibid.*, p. 374.

48. *Automation*, p. 148.

49. *Ibid.*, p. 149.

50. "*Automation—Some Social Aspects*".

51. *Op. cit.*, p. 480.

52. *Automation and Technological Change*, p. 203.

53. *Ibid.*, p. 637.

54. de Bivort, *loc. cit.*

55. Dr. A. V. Astin, Director, National Bureau of Standards (U.S.), in *Automation and Technological Change*, p. 589.

56. *Ibid.*

57. Diebold, in *Automation and Technological Change*, p. 38.

58. Astin, *Automation and Technological Change*, p. 589.

59. *Automation*, p. 33.

60. *Ibid.*, pp. 37-39. Dr. Brunetti told the Congressional subcommittee that it had taken "at least 1,600 man-years of effort to develop printed circuit techniques and materials to their present level of performance. . . . To date, in this country alone, some 1,200 man-years of work have gone into this development at a cost of between 12 to 15 (sic) million dollars, and see how much of it has been automated, and then

ask whether you can push this so fast that you are going to take these plants overnight" (*Automation and Technological Change,* p. 380).

61. Speech by Mr. R. D. Armstrong, Comptroller, C.N.R., to the Winnipeg Chapter of the National Office Management Association, November 21, 1955; by courtesy of Mr. Armstrong.

62. Diebold, *Automation,* pp. 132-3. At p. 35 of his evidence to the Congressional subcommittee, Diebold calls this shortage "critical", and notes that "A recent National Science Foundation study shows that out of the upper 25% of high-school students about half are unable to go to college and another 13% drop out before finishing college. Thus nearly two-thirds of those with the greatest potential for scientific leadership never receive a college education. Less than one quarter of one percent of these ever continue their education through to the doctor of philosophy."

63. Diebold, *Automation,* p. 132.

64. Weinberg, *op. cit.,* p. 6.

65. *Automation,* p. 50.

66. Walter S. Buckingham, in *Automation and Technological Change,* p. 34.

67. *Automation and Technological Change,* p. 55.

68. *Ibid.,* p. 76.

69. *Ibid.,* p. 193.

70. *Ibid.,* p. 109.

71. *Ibid.,* pp. 9-10. Dr. Pragan, Director of Research and Chemical Education for the International Chemical Workers Union, at pp. 152-3, points out how heavy the recent investment in the chemical industry has been: "In 1954 our industry spent $2,240 per production worker for new plant and equipment. This is two and a half times more than the average for all manufacturing industry, which was $877. It has been estimated that approximately 20% of these annual expenditures, used for new plant and equipment, go into automatic control devices. . . . In 1954 (total capital investment per production worker) amounted to $26,665, which is twice as much as the $12,933 investment per worker for all manufacturing industries. Since this figure of $26,665 . . . represents an average for all parts of the industry, it, of course does not do justice to the more mechanized parts of the chemical industry. Take, for instance, the manufacture of ammonia. It is estimated, by the Manufacturing Chemists' Association, that capital investment per production worker comes to $42,500." But these

enormous investments bring enormous returns. *Canadian Chemical Processing,* November 1954, p. 42, estimates the annual output of the automated polyethylene plant at Edmonton at $40,000 per worker.

It is worth noting also that in the last ten years, according to C. W. Bowden, Jr., of the Minneapolis-Honeywell Regulator Company, the rate of expenditure for instruments (in the United States) has grown almost three times as fast as all capital expenditure. The total volume of instrument sales has increased ten times over since 1930. Fifteen years ago, it was unusual to see more than two percent of plant cost going for instruments. Now, in the continuous process chemicals, it is close to 10%, and in one recent plant, it was $2,500,000 out of $15 million.

72. *Automation and Technological Change,* p. 637.

73. *Ibid.,* p. 404.

74. *Ibid.,* p. 446.

75. *Ibid.,* pp. 484-485.

76. *Ibid.,* p. 519.

77. *Ibid.,* p. 575.

78. *Ibid.,* p. 578. Mr. Mitchell, of Sylvania, told the Congressional subcommittee that his company's receiving-tube business alone was "nearly four times greater today than our companywide sales in 1941. . . . Our television-picture tube business . . . is twice as large as our total business in 1941. . . . This is new business that nobody had in 1941. . . . Back in 1938 Sylvania introduced a new product, the fluorescent lamp. . . . From this beginning 17 years ago an entirely new industry has grown, not an industry which supplanted the incandescent lamp industry, but which grew along with it" (pp. 173-175, 179-180).

79. *The Challenge of Automation,* pp. 16-17. Mr. Mitchell told the Congressional subcommittee that the American electronics industry had "a total annual volume of some nine and a half billion dollars, employing more than 700,000 persons. A decade and a half ago, annual volume was about $500 million, and employment of about one-tenth of what we have today. . . . Those are not solely production workers. Those are the distribution workers, salesmen, broadcasters, and so forth, servicemen as well. . . . The most conservative estimates are that the electronics industry will attain an annual volume of $15 billion, or perhaps more, by 1960, and $20 billion by 1964 to 1965, with employment exceeding one million people" (*Automation and Technological Change,* pp. 180-1).

80. James Carey, secretary-treasurer, C.I.O., in *Automation and Technological Change,* p. 223.

81. *Ibid.,* quoting a Department of Labor study of the industry.

82. *Ibid.,* p. 225.

83. *Ibid.,* table at p. 289.

84. *The Challenge of Automation,* p. 38.

85. *Automation and Technological Change,* p. 433.

86. DBS, *Man-Hours and Hourly Earnings,* 1945-1954, and monthly.

87. *Ibid.*

88. DBS, *The Labour Force*

89. *Labour Gazette,* October 1953, p. 1530, and October 1955, p. 1185.

90. *Labour Gazette,* March 1954, p. 436, and May 1955, p. 584.

91. *Labour Gazette,* October 1953, p. 1530, and October 1955, p. 1185.

92. *Labour Gazette,* supra.

93. DBS, *The Labour Force.*

94. DBS, *National Accounts: Income and Expenditure, Fourth Quarter and Preliminary Annual, 1955,* p. 1.

95. DBS, *The Labour Force.*

96. *Automation and Technological Change,* pp. 182-3.

97. *Ibid.,* pp. 427-428.

98. *Ibid.,* pp. 382-384.

99. *Harper's Magazine,* March 1955 (reprint of articles in the March, April, May and June issues, no paging).

100. *Automation and Technological Change,* p. 623.

101. *Ibid.*

102. *Ibid.,* pp. 621-622.

103. *Ibid.,* p. 36.

104. *Ibid.,* p. 57.

105. *Ibid.,* p. 430.

106. *Ibid.,* pp. 153-154.

107. *Ibid.,* table at p. 289.

108. Brief to this Commission, p. II-20.

109. *Automation and Technological Change,* pp. 73-74.

110. *Ibid.,* pp. 444, 446. Mr. Cordiner said General Electric was using 121 computers: 83 for engineering purposes and 38 for data processing. Of 23 other computers which they had ordered, or intended to order, four would be used for engineering and 19 for data processing. As early as 1915, General Electric engineers built an analogue computer to reduce the amount of pencil-and-paper calculations necessary for power system design. The Evendale computer (an IBM 701) "performs repetitive and programme calculations not only for the engineering and test areas within the Evendale plants; it also receives problems over telephone transceiver circuits from our plants in Schenectady, N.Y., and Lynn, Mass. Other departments send in problems by mail. The problems range . . . from the most abstruse nonlinear partial differential equations of supersonic aerodynamics to simple reduction of test data in tremendous quantities. For the most part, these are calculations that could (not) be done without the aid of computers, or would be so expensive that we could not afford to do them. For example, there are certain calculations which will determine the best nozzle and bucket angles in a low-pressure steam turbine. These calculations take from 15 minutes to one hour to do on the computer at Evendale. It is not practical to do this calculation by hand since it would require from one to three years of continuous, error-free hand calculation for each turbine. . . . Guided and unguided missiles would be practically unthinkable without computers to calculate their trajectory. . . . The computers have greatly speeded the development of jet engine and airframe designs. . . . The computers are not substitutes for engineers. . . . The very companies which are using computers are the ones who are also increasing their engineering staffs. These computers help to create so much more scientific information, and introduce so many more technical possibilities, that we need more engineers to put the new information to work. . . . The computer opens up scientific possibilities that were unthinkable before, and will make possible new products and industries that we cannot possibly foresee. . . . To the people in our Evendale plant, the computer is extremely important to their continued employment. Our engineers with their computers must continue to come up with ever-better jet engine designs to serve the needs of our military and commercial customers, so that we will have employment for the more than 12,000 General Electric employees at Evendale. Here is the real impact of the computer on employment stability; not simply providing employment for 80 more people in the computer section but maintaining employment for more than 12,000 people in our Evendale plant, and helping to create new industries that will someday employ thousands more" *(ibid.,* pp. 443-445).

111. *Industrial Canada,* January 1956, p. 43.

112. *Automation and Technological Change,* p. 74.

113. *Ibid.,* p. 35.

114. Brief to this Commission, pp. II 20-21.

115. *Automation and Technological Change,* p. 587.

116. *Ottawa Journal,* editorial of May 5, 1956.

117. *The Saturday Evening Post,* April 28, 1956, p. 84.

118. *Automation and Technological Change,* pp. 63, 66. Mr. Davis (p. 64) added that Ford had done "a lot of encouraging with various universities, bringing people in each year on special courses".

119. *Ibid.,* p .157. Note also the article in *Time,* December 5, 1955. "Over half a century and more, labor has profited, along with industry, by continuous solutions of the problem of competition with the machine. The electronic age makes the problem all the more complicated. Last week in a night class in Los Angeles, a dozen members of the United Steelworkers of America (C.I.O.) took a step toward preparing themselves for the day of the automated factory. Wedged behind desks built to suit the proportions of their teen-age children, the men (average age: 36) listened intently to 31-year-old Stanley Hauer, instructor and planner of their pilot course, who sat in his shirtsleeves atop his desk as he lectured.

"Chiefly responsible for the educational project is Cass D. Alvin, the Steelworkers' western regional educational director. Alvin likes to cite a page of labour history as the wrong way to cope with the problem: England's 19th century 'Luddites' tried to stem the infant Industrial Revolution by smashing up the new machinery. Says Alvin: 'We could kick these new electronic machines like the Luddites did, but they wouldn't give a damn.'

"Last summer, instead of kicking the machines, Alvin and Joseph E. Doherty, one of the union's business representatives, asked Industrial Engineer Hauer to draft an experimental course that would make electronic technicians out of the union's semi-skilled machine-tenders, the most vulnerable targets of automation. With the help of Donald B. Levinson, a Hughes Aircraft electrical engineer, and RCA Electronic Technician Joseph Schoen, Hauer settled on a night curriculum. The class will meet twice a week for four years, start with the simplest math problems but eventually lead the students through basic courses in radar, physics and electronics. The course outline has been accepted by the state-supported adult education programme. The classes are open

to non-union registrants, and the only tuition for the course is a 25¢ token fee required by the high school where the classes are held. Hauer set the pace at a slow academic rate; he gives no tests, receives class papers unsigned ('Each one of these men came convinced he's the only dumb one in the class').

"More than 50 steelworkers have already signed up, and Alvin knows that watchful eyes at the 1,200,000-member union's headquarters are on the project. Says he: 'Automation's a scare word, but if we're going to scare our men, let's scare them intelligently. There's no point in telling them a second flood is coming and nobody knows where the ark is. Our four-year course is our ark.' "

120. *Ibid.,* p. 385. Mr. Cordiner said that General Electric "provides any training required to enable employees to handle new assignments. Most of this training is informal in nature, and is done by individual supervisors on the job or through vestibule training schools that run from one to two weeks, in preparation for a specific kind of work. In addition, our company conducts more than a thousand courses in factory skills and at least 500 courses at its various locations for professional, technical and semitechnical personnel in the areas of finance, manufacturing, engineering, supervision and management, and marketing. We estimate that in an average year one out of every eight General Electric people at all levels of the organization takes advantage of company-conducted courses. We estimate that we spend on (sic) the order of 35 to 40 million dollars a year to train or retrain our employees. This figure includes the time and scrap and waste resulting from inexperience and the training needed. . . . In addition, we have an expanding programme of support for education generally, which, in 1956, will include $1,400,000 in scholarships, grants, and fellowships" (pp. 431-2). Note also his memorandum at p. 449.

121. *Ibid.,* p. 75.

122. *Ibid.,* p. 93.

123. *Ibid.,* pp. 384-385.

124. *Ibid.,* p. 614.

125. *Ibid.,* p. 386.

126. *Ibid.,* p. 62.

127. *Automation,* pp. 133-137.

128. *Automation and Technological Change,* p. 615. Dr. Brunetti told the subcommittee, at pp. 379-380: "Now, in the interest of time, I have prepared a statement about small business as well as big business, and

I would like to just thumbnail through that quickly, without giving too much of the figures.

"We got figures for this year on the total investment of a thousand plants. (This, again, was done by a magazine, Penton Publications, who surveyed several thousand plants and got replies from about a thousand of them. This is published in Steel Magazine, March 28, 1955).

"Almost a thousand plants replying reported that in 1955 these small businesses were going to, well, the total was going to be $350 million spent for new equipment. Of this total, $125 million was to be spent by small- and medium-size businesses, and $225 million by large businesses.

"In 1956, their estimate showed that the small and medium business spending will average $225,000 and $290,000, respectively, small and medium, while the large businesses' average spending for new equipment will be $475,000.

"This shows that small business is not standing by and waiting for big business to take over and run the economy from now on. In the major factor that determines the success of a small business, or, for that matter, any business under competitive conditions; namely, price, we all know that in many cases small companies can outperform the big ones. Lower overhead, greater flexibility, and more direct supervision are some of the reasons. All manufacturers, large or small, depend on a multitude of parts suppliers who are in general small, specialty manufacturers. In the electronics industry alone we have 55,000 varieties of components, and can one manufacturing company become efficient in the production of all these, let alone have the capital to set up these lines, or even what is more to have the management capability to handle all this in one big business?

"Most of these components are supplied by the small companies, each specializing in its own field and doing a remarkable job in the field of low-cost production. Few, if any, of the larger companies will find it worth while to try to compete.

"Now, at General Mills we found in connection with Autofab—I will try to go through this quickly—we found that there are probably some 3,000 manufacturers that would be interested in Autofab, in one way or another. From those that came to us, and we have had hundreds come to Minneapolis to look it over and to talk to us about it, we find that only one or two percent of the total electronics industry can use the large installation—the large industries represent only one or two percent of the total in the electronics industry. The volume that we expect to sell, or, let me say that the United States expects to sell, because we are

not the only one in this business—as I mentioned before, competition comes in just pretty fast, and there are others trying to sell the same kind of a machine—may amount to $30 million.

"If that volume is $30 million for large business, our estimate is that medium-sized business volume will also be approximately $30 million, the total volume of that equipment in the United States; whereas small business—and this is equipment not in the $160,000 class like we had up on the chart, but in the $15,000 class, the volume appears to be something in the neighborhood of 40 to 45 million dollars. In other words, the volume for an automatic-machine producer is greater in the small- and medium-size businesses than it is in the large business.

"That is where we are going to concentrate our attention. At this time we are developing two new kinds of machines, a Unifab and short-run Autofab, which are in what you might call the three to 15 thousand dollar class, partly automated, partly manual, for the small manufacturer, which will boost him right along with the large manufacturer."

129. *Automation,* pp. 137-138.

130. *Automation and Technological Change,* pp. 11-14.

131. *Ibid.,* pp. 147-148.

132. *Ibid.,* pp. 625-626. Several witnesses before the Congressional subcommittee said they thought automation would help to stabilize the economy, notably because automation involves such large investments. We are not much impressed by such arguments. The capital-goods industries have long involved very large investments, but employment in them has been notoriously unstable. The causes of economic fluctuations lie, we think, much deeper, and will not be much, if at all reflected by automation.

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[1]This is one of a series of three studies on Canadian international economic relations prepared under the direction of S. S. Reisman.

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